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ABUNDANCE ESTIMATES OF THE
ESCAPEMENT OF CHINOOK SALMON INTO
THE KENAI RIVER, ALASKA, BY
ANALYSIS OF TAGGING DATA, 1989[1]

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ABSTRACT

Drift gill nets were used to capture adult chinook salmon *Oncorhynchus tshawytscha* in the lower Kenai River for tagging. Tagged fish were recovered during a creel survey of the recreational fishery and an upriver drift gill net fishery. The number of chinook salmon entering the Kenai River from 17 May to 7 August was estimated using the tag release-and-recapture data. The estimated total return of chinook salmon to the lower Kenai River from 17 May to 7 August was 80,532. The abundance of late-run fish (57,279) was more than double that of early-run fish (23,253). The major age group of returning chinook salmon was 1.4 (68 percent). The sonar estimate of abundance was 47,037 chinook salmon, almost half of the tagging estimate. However the sonar estimate was within the 95 percent confidence interval of the tagging estimate (46,951-114,113). The imprecision of the tagging estimate was due to low sampling rates both in the marking and the recovery efforts. The mean length-at-age of all age classes of male and female chinook salmon increased throughout the return.

KEY WORDS: Kenai River, chinook salmon, *Oncorhynchus tshawytscha*, tag release-and-recapture, abundance estimate, gill net effort and catch statistics, age-sex-length compositions.

INTRODUCTION

Alaska's largest recreational fishery in fresh water occurs in the Kenai River. More than 320,000 angler days of effort were expended in this fishery in both 1985 and 1986 (Mills 1986, 1987) and nearly 290,000 angler days were expended in 1987 (Mills 1988). In 1988, effort increased to an historic level of 374,000 angler days (Mills 1989). Most of the effort by anglers is directed at returning chinook salmon *Oncorhynchus tshawytscha* and occurs during June and July in the mainstem of the river downstream from Skilak Lake (Figure 1). In 1989, both angler-effort and harvest of chinook salmon by this fishery as estimated from a creel survey (Hammarstrom 1990) declined from the record levels of 1988 (Figure 2). This decline was due to the small run which returned to the Kenai River in 1989 (Table 1). However, fishing effort is expected to remain at high levels because the Kenai River is near a major population center, is easy to access, and is world-famous for the large size of its chinook salmon.

The Kenai River has two stocks of chinook salmon: (1) an early run which enters the river from mid-May until late June, and (2) a late run which enters the river from late June through early August. Fish from both stocks are highly valued by anglers because of their large size, especially fish from the late run. Chinook salmon in the late run average about 18 kg (40 lbs) and often exceed 36 kg (80 lbs). The world record for a sport-caught chinook salmon was taken from the Kenai River in 1985; it weighed 44 kg (97 lbs).

In the fall of 1988, the Board of Fisheries made the decision to separate the early and late run arbitrarily at July 1 for the purpose of in-season management. Although the definitions of the early run (17 May to 30 June) and the late run (1 July to 07 August) are convenient representations of the timing of the runs, in reality there is overlap of their timing.

Management of the recreational fishery in the Kenai River is complicated by the relatively large harvests of chinook salmon returning to the Kenai River by sport and commercial fisheries in the marine waters of Cook Inlet, particularly by the commercial set net fishery along the east side of the Inlet (McBride et al. 1985). Estimates of the abundance and biological characteristics (age and sex compositions, mean length at age) of the Kenai River chinook salmon escapement are needed to effectively manage the sport fishery. The Sport Fish Division of the Alaska Department of Fish and Game (ADFG) proposed a tag release-and-recovery program in 1975 to provide the required estimates. Electrofishing equipment, drift gill nets (Hammarstrom 1980), fish traps, and fish wheels (Hammarstrom and Larson 1982, 1983, 1984) were tested as methods of catching chinook salmon for tagging. Drift gill nets were found to be the most effective and were used to estimate abundance of late-run chinook salmon in 1984 (Hammarstrom et al. 1985). The abundance of both runs of chinook salmon has been estimated through tagging since 1985 (Hammarstrom and Larson 1986, Conrad and Larson 1987, Conrad 1988, and Carlon and Alexandersdottir 1989).

The feasibility of using hydroacoustics (i.e. sonar) to estimate inriver return has been investigated since 1984, and the first estimates were produced in 1987 for the late run of chinook salmon and in 1988 for the early run. The
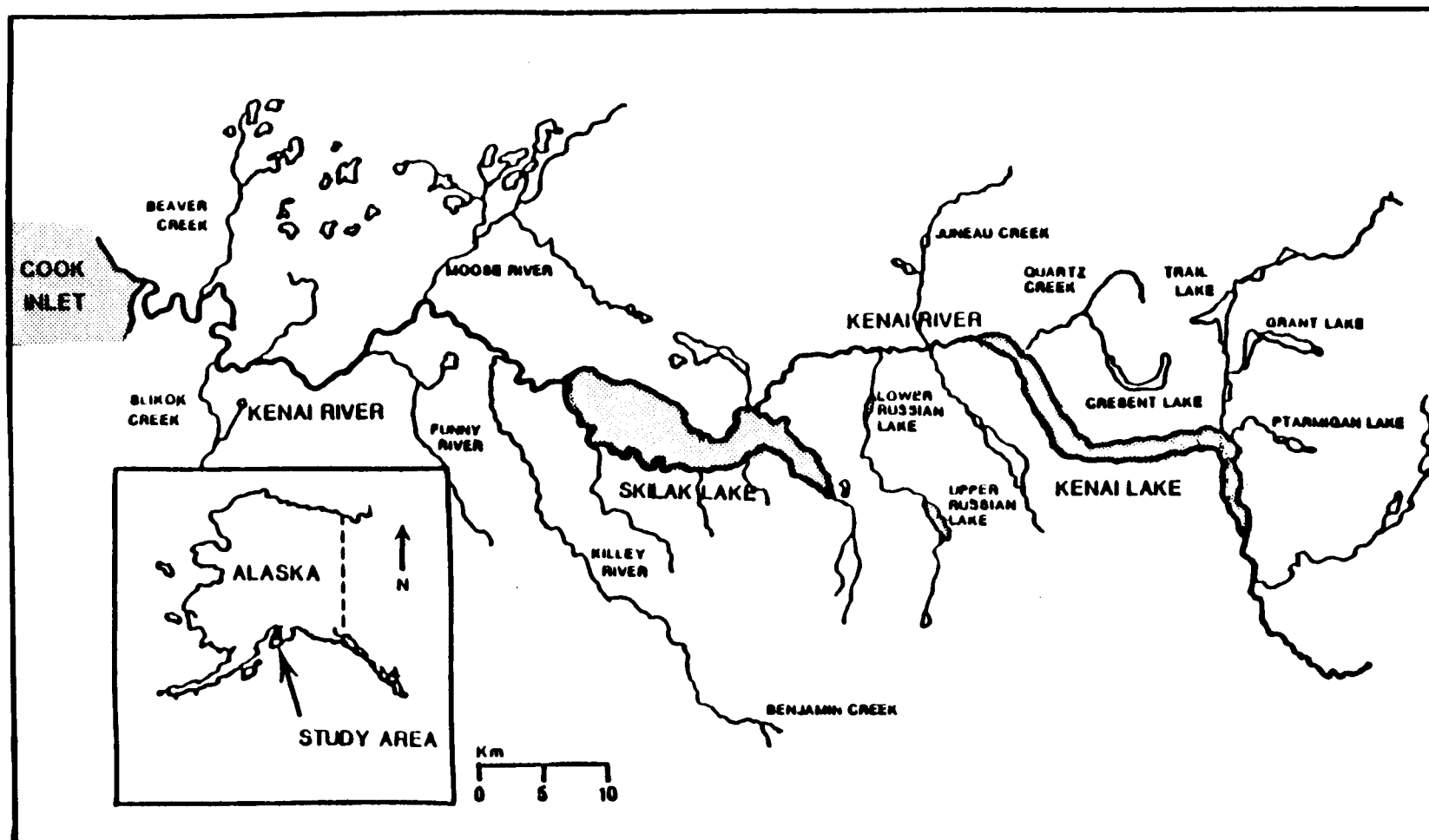
Figure 1. Map of the Kenai River system.
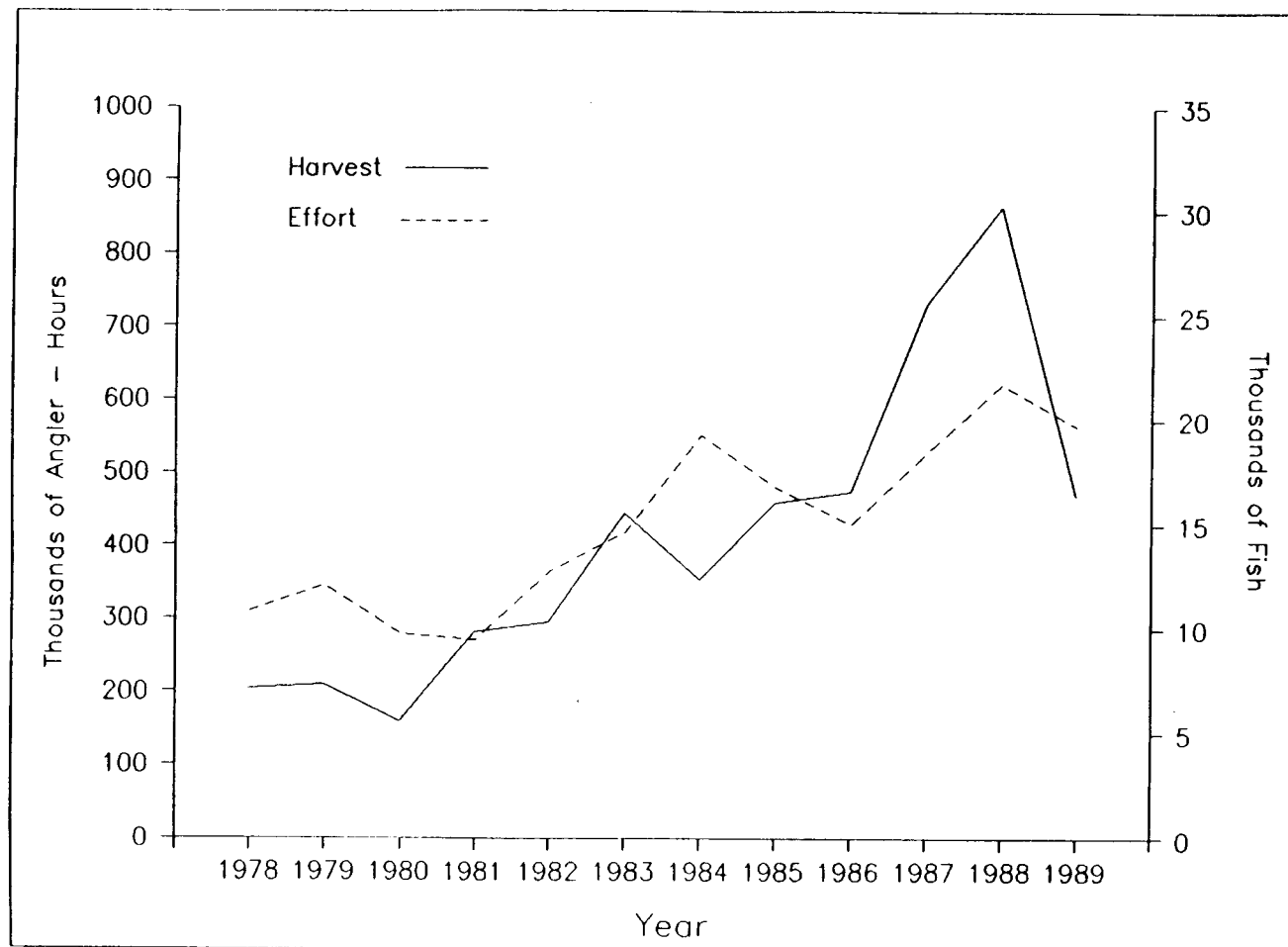
Figure 2. Estimates of angler-effort and harvest of chinook salmon for the recreational fishery in the Kenai River during May, June, and July, 1978-1989 (Hammarstrom 1990).

Table 1. Estimates of inriver abundance[a] of Kenai River chinook salmon 1986-1988.

	Early run			Late run			Total run		
Year	Tag[b]	SE	Sonar[c]	Tag	SE	Sonar	Tag	SE	Sonar
1986	27,080	6,860		57,563	11,782		84,643	10,602	
1987	25,643	4,597		65,024	24,592	48,123	90,667	24,877	
1988	25,047	4,777	20,880	110,869	25,143	52,008	135,916	24,582	72,888

[a] Inriver abundance = abundance estimated migrating past tagging fishery and sonar before exploitation in sport fishery.

[b] Tag = abundance estimated in tagging fishery.

[c] Sonar = abundance estimated by sonar project.

sonar estimate of abundance is generally lower than the tagging estimate, however the differences were not significant with the exception of the 1988 estimate of the late run (Table 1).

This report presents the abundance estimates for chinook salmon in the escapement to the Kenai River during 1989, and also presents biological data from chinook salmon sampled during tagging and spawning ground surveys.

METHODS

A mark-recapture study was used to estimate abundance. Tag releases and recoveries were stratified by time periods. The study was designed with strata of 2 weeks from 17 May to 11 August, with the first three periods representing the early run and the last three the late run. Drift gill nets were used to capture fish for tagging and recovery was effected through the creel survey in the sport fishery from 17 May to 31 July, and through an up-river drift gill net fishery in August.

Tag Releases

In 1986, it was found that competition occurred if four crews fished gill nets simultaneously (Conrad 1987), and therefore, in 1987, 1988, and 1989 there were never more than three crews sampling at one time. Tagging was conducted between 11 km and 15 km upstream from the mouth of the Kenai River (Figure 3) each day from 17 May through 7 August, inclusive. Two crews usually operated on 4 days of each week and all four crews operated on the remaining 3 days of each week.

Sampling could be conducted during daylight hours only and was restricted to the 9 hours before high tide because catches of chinook salmon were highest during this period in other years (Hammarstrom and Larson 1982, 1983, 1984). The efficiency of the drift gill netting technique is greatly reduced by the high river levels and reduced river velocities encountered near high tide. Two crews worked each tide on days when two high tides occurred during daylight. When only one high tide occurred during daylight, either two or three crews operated depending on crew availability. Each sampling period was about 6.5 hr long.

Each crew used a 19 cm stretched-mesh drift gill net about 15 m long to capture chinook salmon. The net was set from the bow of an outboard powered skiff by releasing one end of the net near the shoreline and rapidly backing the skiff toward the middle of the river channel. Once the net was extended, it was allowed to drift downstream with the current until either a fish was caught, the net encountered a snag on the river bottom, or the boundary of the tagging area was reached.

When a fish became entangled in the net, the floats on the net bobbed violently and the net was then immediately retrieved. A soft, braided rope was looped around the caudal peduncle of each chinook salmon captured. The fish was then untangled from the net and slipped into a cradle for processing. The tagging cradle was a rigid, foam-padded device which hung from the side of
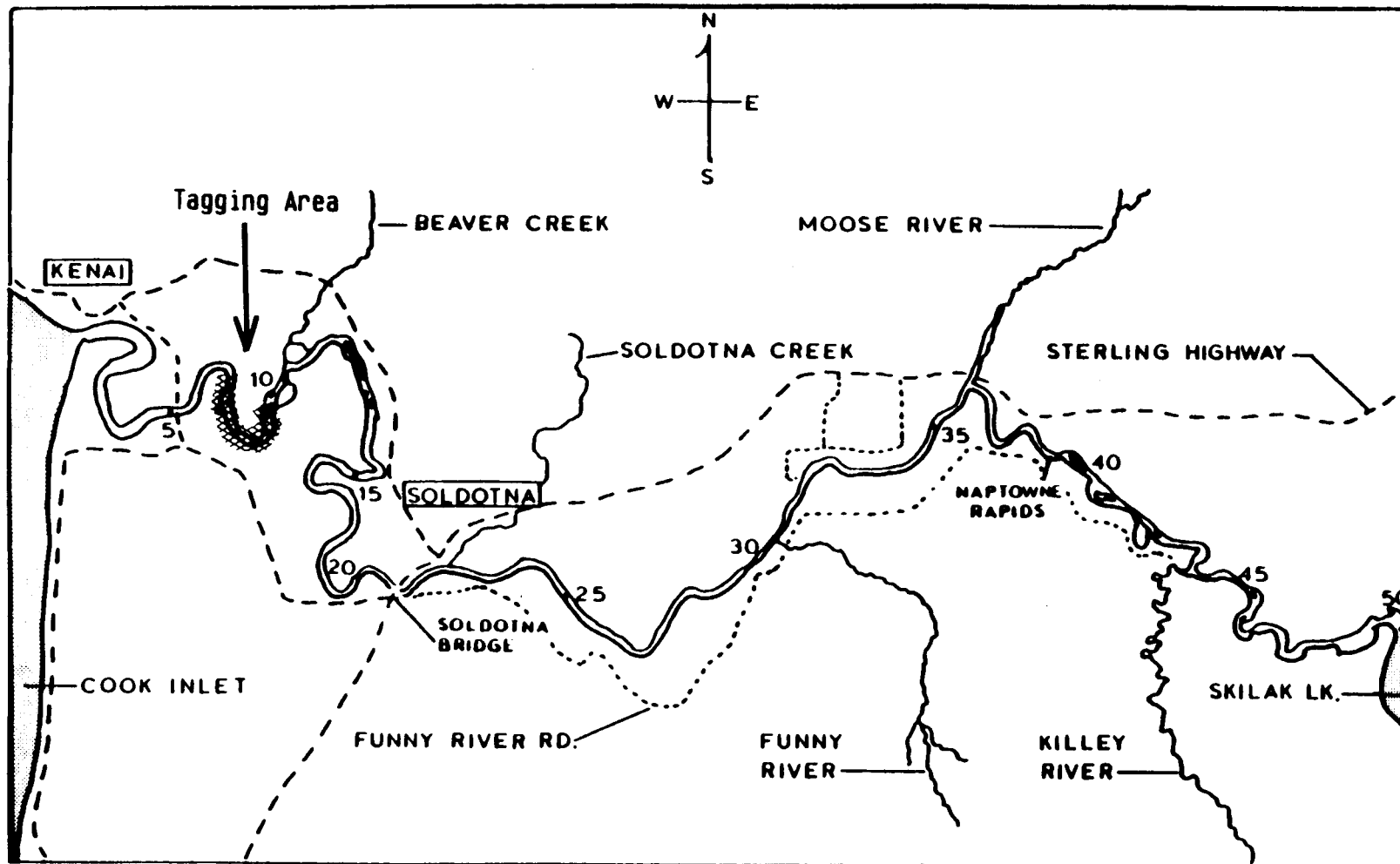
Figure 3. Map of the lower Kenai River between Cook Inlet and the outlet of Skilak Lake.

the skiff with its base about 15 cm below the water line. The cradle immobilized the captured fish and kept it in the water during processing. The date, time of capture, and approximate location of capture were recorded for each chinook salmon brought to the skiff, in addition to the tag number for fish tagged.

The condition of each captured chinook salmon was assessed prior to tagging. Chinook salmon with deep scars, damaged gill filaments, a lethargic condition, or fish requiring extended processing time were not tagged. Fish were tagged with individually numbered Floy FT-4 plastic spaghetti tags cut to 50 cm lengths. A different tag color was used during each approximate 2-week temporal stratum. Identifying each release stratum with a different tag color allowed tags recovered with no recorded tag number (due to an omission by the creel survey technician) to be associated with a release stratum for the abundance estimate. The following tag colors were used during the specified temporal strata:

orange	-	17 May	through 31 May,
green	-	1 June	through 14 June,
white	-	15 June	through 30 June,
yellow	-	1 July	through 15 July,
blue	-	16 July	through 31 July,
red	-	1 August	through 7 August.

Each tag was inserted below the posterior insertion of the dorsal fin with a large needle and secured with an overhand knot. The mid-eye to fork-of-tail length (measured to the nearest 10 mm) and the sex (identified from inspection of external characteristics) of tagged fish were recorded. Three scales were removed from the preferred area (Clutter and Whitesel 1956) of each chinook salmon and mounted on an adhesive-coated card.

Effort and catch for each set with the gill net were recorded. Effort was measured as the number of minutes the net drifted before being retrieved and catch as the number of chinook salmon caught. Captured chinook salmon were tallied according to five categories: (1) untagged fish which were captured and tagged, (2) untagged fish which were captured but not tagged because of their poor condition, (3) fish which were captured and positively identified as chinook salmon but escaped before being processed, (4) previously tagged fish which were recaptured, and (5) fish with healed adipose finclips. Any chinook salmon with a healed adipose finclip was sacrificed so that the head could be inspected for the presence of a coded-wire tag (CWT). The tag numbers of fish in category 4 were recorded.

Tag Recovery

The inriver recreational fishery, which is restricted by regulation to the area between the outlet of Skilak Lake and Cook Inlet, was one of two mechanisms utilized in 1989 for tag recovery.

A creel survey of the fishery was used to estimate the proportion of chinook salmon in the river that were tagged for the period 15 May through 31 July. Nearly all sport fishing in the Kenai River occurs upstream of the area where

the tagging occurred. The fishery and the creel survey for 1989 are described in detail by Hammarstrom (1990).

The creel survey was conducted in the downstream (Cook Inlet to Soldotna Bridge) and upstream (Naptowne Rapids to the outlet of Skilak Lake) sections of the Kenai River (Figure 3). In 1989, approximately 84% of the angler-effort and 90% of the chinook salmon harvest occurred in the downstream section (Hammarstrom 1990). The downstream section was surveyed between 17 May and 30 July and the upstream section was surveyed from 6 June to 30 July.

Anglers were interviewed for effort, harvest, and catch rate information primarily at seven popular boat landings in the downstream section:

1. Soldotna Bridge (RKM 34.6),
2. Centennial Park (RKM 33.0),
3. Poacher's Cove (RKM 28.2),
4. King Run resort (RKM 24.5),
5. Big Eddy jetty (RKM 22.5),
6. Big Bend campground (RKM 22.4), and
7. Eagle Rock (RKM 18.5).

Two access-site creel survey technicians were primarily responsible for obtaining interview data at these seven sites. Additional angler interviews were collected from anglers who had completed their fishing day at other, less utilized sites, by two roving creel survey technicians, if time was available during their shifts. The two roving creel personnel were further responsible for anglers who were still on the river but not actively fishing, as these anglers had most likely already caught a fish. These observations were conducted after the required boat angler counts were obtained which are necessary for estimating effort in the fishery.

An additional roving creel survey technician was responsible for obtaining interview data from completed anglers in the upstream section at two launch sites (Bing's Landing, RKM 63.5; Dot's Landing, RKM 70.8) and incomplete anglers fishing the mainstem between RKM 63.5 and RKM 80.4.

The following information was recorded for each angler interviewed: (1) completed-trip or incomplete trip angler, (2) guided or unguided angler, (3) number of hours spent fishing, (4) number and species of fish retained, (5) number and species of fish released, and (6) number of chinook salmon present with a tag or a tagging wound in the event of tag loss. In addition, the following information was recorded for tagged chinook salmon: date and time of capture, location of capture, and tag color and tag number. Untagged chinook salmon were inspected for the presence of a tagging wound.

If an angler interviewed at an access-site location had a chinook salmon in possession, the creel survey technician asked if the fish had been previously observed by a roving creel technician. If the chinook salmon had been previously examined by a roving creel survey technician, the fish (whether tagged or untagged) was recorded and flagged as a prior observation and the fish was removed from the totals for the access site recoveries.

In 1989, an additional tag-recovery effort was carried out after the conclu-
sion of the sport fishery for chinook salmon. Drift gill nets were used to
capture chinook salmon in the mainstem Kenai River from the Soldotna Bridge
downstream to Eagle Rock, which is above the area used by the tagging crews.
This recapture effort began on July 31 and was discontinued on August 11.

The drift gill netting techniques used were identical to those employed during
the tagging procedure. The net was set from the bow of the boat and the boat
was allowed to drift with the river current until a fish was caught (indicated
by the violent bobbing of the floats on the net) or the net became entangled
on a snag in the river. There were no established boundary areas but
arbitrary limits were established each day to allow the crews to maintain
radio contact in case of accidents. The fish were processed similarly to
methods used for the chinook salmon which were tagged. The captured chinook
salmon was immobilized in the padded cradle suspended in the water; sex and
length recorded, and condition noted. Tagged fish were observed for tag color
and number which were then recorded. The date, time of capture, and approxi-
mate river mile of capture were also recorded for each chinook salmon brought
to the skiff.

Effort and catch for each set with the gill net were recorded in a manner
similar to the procedures employed in the initial tagging operation. Effort
was measured as the number of minutes the net drifted before being retrieved
and catch as the number of chinook salmon caught. Captured chinook salmon
were recorded according to six categories: (1) untagged chinook salmon
captured, (2) tagged chinook salmon captured, (3) fish which were captured and
positively identified as chinook salmon but escaped, (4) previously untagged
fish which were recaptured, (5) previously tagged fish which were recaptured,
(6) fish with healed adipose finclips. The mid-eye to fork-of-tail length and
the sex of all untagged fish were recorded. No scales were removed for age
determination from any of the captured fish.

Upon initial capture of an untagged fish, the caudal fin was punched with one
hole. This event was recorded, the condition of the fish noted, and the fish
was released. The recapture of a spaghetti-tagged fish was observed with the
recording of the tag number and the punching of the caudal fin. In the event
of a subsequent recapture of either a tagged or untagged chinook, the fish
received a second caudal punch to indicate that the fish had been captured
twice and the event recorded.

Spawning Ground Surveys

Chinook salmon carcasses from spawning grounds on the mainstem of the Kenai
River were sampled to estimate age, sex, and length compositions. The area
from Cook Inlet to Soldotna Bridge was surveyed from 20 September to
21 September. During the fall months of 1989, flood level conditions
prevented additional surveys in other areas of the mainstem Kenai and
decreased the number of carcasses remaining in the accessible area of the
river. The mainstem is the primary spawning area for late-run chinook salmon
(Burger et al. 1985).

All chinook salmon carcasses observed during the surveys were measured for mid-eye to fork-of-tail length (measured to the nearest 10 mm), the sex was identified, and three scales were removed from the preferred area and mounted on an adhesive-coated card. The number of any tag present and the presence/absence of a tagging wound were also recorded. The body cavity of all chinook salmon carcasses was cut open to prevent duplicate sampling and to determine the proportion of unsuccessful spawners.

Biological Data

Length Distributions:

All fish tagged and released were measured, as were all fish taken in the August gill net fishery. A sample of sport caught chinook salmon was also measured in the creel survey. In order to test for selectivity in these fisheries, the following comparisons were made:

1. the distribution of salmon released in the tag fishery was compared to fish recovered a second time in the same fishery by run,

2. the distribution of fish recovered in the creel survey and August fishery were compared to the tag releases by run and recovery method,

3. the distributions of all fish sampled in the release fishery were compared to the recovery samples by run and recovery gear (creel and gill net).

Non-parametric Kolmogorov-Smirnov tests (Conover 1980) were used to test the null hypotheses that these length distributions were the same.

Age Compositions:

The age compositions of the chinook salmon tagged and those sampled during spawning ground surveys were estimated from the scale samples collected. The biological data were separated into bimonthly periods. Letting p_{ghj} equal the proportion of the sample from time period j belonging to sex g and age group h, the variance of p_{ghj} was estimated as a binomial variance (Scheaffer et al. 1979):

$$V(p_{ghj}) = p_{ghj}(1-p_{ghj})/(n_{Tj}-1),$$ [1]

where, n_{Tj} is the number of legible scales read from chinook salmon sampled during the jth period. Chi-square tests were used to test for differences in age compositions by run, period, and sex, and for differences in sex composition by run and period.

Mean length at age by sex and its variance were estimated using standard procedures for normally distributed random variables.

Abundance Estimation

Tag Releases and Recoveries:

In 1989, there were no tag recoveries obtained in the upstream creel survey. Therefore, it was not necessary to test the two different recovery samples (upstream roving survey and downstream access-site survey) for equality of recovery rates.

Constant probabilities of capture at times of tagging and recapture are important assumptions necessary for the Petersen estimator of abundance (Seber 1982). When tagging and recovery occur over an extended period of time these assumptions can be violated. The tagging data were tested to determine if they were consistent with these assumptions. The first hypothesis tested states that the probability of recapture is equal for all release groups. The second states that the ratio of tagged-to-untagged fish is equal for all recapture strata, i.e. an equal proportion of the population is tagged in all strata. If neither of these tests results in a rejection of the null hypotheses, then the Petersen estimator can be used. Otherwise, a stratified estimator must be used, as has been the case in all years of this project.

When there are equal numbers of release and recovery strata, the stratified estimator (W) is (Seber 1982):

$$W = D_u M^{-1} a \qquad\qquad [2]$$

where:

   W = a vector with the estimates of the number of <u>untagged</u> chinook salmon in each tagging stratum <u>just after the release of the tagged fish</u>,

   D_u= a diagonal matrix of the number of untagged fish observed in each recovery stratum j,

   M = a matrix of m_{ij}, the number of tagged fish in each recovery stratum, j, which were released in tagging stratum i, and

   a = a vector of the number of tagged fish released in tagging stratum i.

The number of chinook salmon in each stratum at the time of tagging is the sum of the estimated number of untagged fish present and the number of tagged fish released in the stratum.

The variance-covariance matrix of W was estimated with (Seber 1982):

$$E[(\hat{W}-W)(\hat{W}-W)'] = D_w B^{-1} D_u D^{-1}_a B'_{-1} D_w + D_w(D_p - I) \qquad\qquad [3]$$

where,

   D_w = diagonal matrix of estimated abundance in each stratum,

   D_p = diagonal matrix of reciprocals of p_i, which is the estimated probability of an animal surviving and being caught,

B′ = matrix of b_{ij}, the probability that a member of a_i is in stratum j at sampling and that it is alive,

I = the identity matrix.

The variance of the point estimate for the total number of chinook salmon present is the sum of the variance and covariance estimates for the individual strata.

Assumptions necessary for the stratified abundance estimates are (Seber 1982):

1. All chinook salmon in the jth recovery stratum, whether tagged or untagged, have the same probability of being harvested (caught and kept) by the recreational fishery.

2. Tagged fish behave independently of one another with regard to moving among strata and being caught.

3. An angler is as likely to release a tagged chinook salmon as an untagged fish.

4. There is no tag loss, either naturally or by anglers removing tags, from chinook salmon which are caught and subsequently released.

5. All tagged fish are recognized as such during recovery.

6. There is no tagging induced mortality.

Bootstrap techniques (Efron 1982) were used to estimate the bias due to sampling. The tag histories were resampled 1,000 times, and for each sample the abundance by stratum was estimated as above. The bias was estimated as the difference between the bootstrap mean and the estimate calculated from the original sample.

Catch and Effort Indices:

This year (1989) was the first year that an upriver gill net recovery fishery was carried out in August. In prior years, catch and effort statistics from the gill net fishery were used to estimate abundance for August after the sport fishery was closed. Although tag releases and recoveries were made in August of 1989, the catch/effort analysis was also carried out for the purposes of comparison. In order to do this, the last release/recovery strata is dropped and a tag estimate generated for the remaining strata during the period 20 May to 28 July.

The data from all sets by all crews were combined to calculate the statistics for each of the temporal strata (Table 2). The correlations between the statistics and the estimated abundance of chinook salmon were then calculated.

Table 2. Definitions of the effort and catch statistics analyzed.

	Acronym	Definition
1.	TOTSETS	The total number of drift gill net sets made during a stratum.
2.	TOTEFF	The total number of minutes of gill net effort during a stratum.
3.	MNDUR	The mean duration (in minutes) of the gill net sets during a stratum.
4.	TOTCAT	The total catch of chinook salmon during a stratum.
5.	MNCAT	The mean catch of chinook salmon per gill net set during a stratum.
6.	MNCPUE	The mean of the individual set CPUE during a stratum.
7.	CPUE	The quotient of the total catch of chinook salmon and the total effort during a stratum.
8.	TOTEFF=0	The total number of minutes of effort by sets which caught no chinook salmon during a stratum.
9.	MNDUR=0	The mean duration in minutes by sets which caught no chinook salmon during a stratum.
10.	%EFF>0	The percent of the total effort (in minutes) during a stratum by sets which caught at least one chinook salmon.
11.	SETS>0	The total number of drift gill net sets which caught at least one chinook salmon during a stratum.
12.	%SETS>0	The percent of the total number of sets that caught at least one chinook salmon during a stratum.
13.	MNDUR>0	The mean duration in minutes of sets which caught at least one chinook salmon during a stratum.
14.	SETS/CD	The mean number of sets per crew-day during a stratum.
15.	EFF/CD	The mean number of minutes of effort per crew-day during a stratum.
16.	CAT/CD	The mean catch of chinook salmon per crew-day during a stratum.
17.	SETS>0/CD	The mean number of sets per crew-day that caught at least one chinook salmon during a stratum.

The relationship between estimated abundance and the effort/catch statistics was assumed to be the same for all years and the data for all years were combined (Conrad and Larson 1987, Conrad 1988). The number of days in the strata varies considerably so the estimated abundance of chinook salmon for each stratum was divided by the number of days in the stratum for a mean number of fish present per day.

The statistics with the highest correlation were used to build linear, power, and exponential models describing mean chinook salmon abundance per day as a function of the effort/catch statistic. The models were (Zar 1974):

for the linear model, $Y = aX + b,$ [4]

for the power curve, $Y = aX^b,$ and [5]

for the exponential curve, $Y = ae^{bX},$ [6]

where:

Y = the estimated mean abundance of chinook salmon per day,

X = the effort/catch statistic, and

a and b are regression coefficients.

Procedure NLIN of SAS (SAS Institute, Inc. 1982) and the Marquardt method of minimizing the error sum-of-squares were used to calculate least-square estimates for the parameters of the nonlinear models. The mean squared error and precision of the parameter and abundance estimates for the models were examined to select the model to estimate the number of chinook salmon entering the Kenai River from 31 July to 7 August.

The variance of this estimate of abundance was estimated empirically by Monte Carlo simulation. Rubinstein (1981) describes a procedure for generating values from random variates with a multinormal distribution using the variance-covariance matrix of the variates. The regression parameters (a and b) represent a vector of random variates and, using the variance-covariance matrix for a and b supplied by procedure NLIN, 1,000 new estimates of the regression parameters are generated. These were then used to generate 1,000 estimates of abundance using the value of the effort and catch statistic. The variance for the estimate of chinook salmon abundance was then calculated empirically from the 1,000 estimates.

RESULTS

Sampling took place between 20 May and 11 August, during which period 1,991 chinook salmon were tagged and released, 1,531 examined for tags in the creel survey, and another 529 examined for tags in the upriver gill net fishery in August.

Length Distributions

Comparison of Early and Late Run Releases:

The length distributions of fish tagged and released during the early and late runs were significantly different (Table 3, p = 0.001). Large fish (> 100 cm) represented 50% of the late run and 30% of the early run (Figure 4). Also, the late run sample had a bimodal distribution, while the early run was skewed to the left (Figure 4).

Selectivity in the Tagging Fishery:

During the tagging fishery, 138 tagged and released chinook salmon were recaptured a second time. The length distribution of these recoveries was compared to the release for each run to test whether selectivity had occurred. Those recaptured again in the tagging fishery during the early run were found to be significantly larger (Table 3, p = 0.0015) than the initial releases indicating that the tagging gear was selecting larger fish during the early run, but a similar test was not significant for the late run (p = 0.65). A population estimate for the early run can only include that segment of the population that is recruited to the tagging fishery gear, and will be a minimum estimate.

Comparisons of the tagged releases to recoveries of tagged fish in the creel survey sample (Table 3) were not statistically significant for the early releases recovered in the creel survey (p = 0.95), late releases recovered in the creel survey (p = 0.40) or the August recovery fishery (p = 0.62). However, during the late run, no chinook salmon under 75 cm were sampled from the harvest (Figure 5) while approximately 15% of the tagged population was under this size. Therefore, the population estimate should be stratified into two size groups, salmon smaller than and larger than 75 cm.

A comparison of the length distribution of all fish sampled in the recovery sample to all fish sampled in the release sample (Table 3, Figure 5) was significantly different for the late run creel survey sample (p = 0.01), but was not significant for the early run creel sample (p = 0.08) or August gill net recovery sample (p = 0.06) at an alpha level of 0.05. However, these last two tests are significant at an alpha level of 0.10. Examination of the cumulative distributions (Figure 5) indicates that during the early run the harvest was also selective for larger fish. During the August recovery fishery, sample sizes were large, and the distributions (Figure 5) are not visibly different even though the p-value is close to 0.05.

Age Composition

Age 1.3 and age 1.4 chinook salmon composed 15.0% and 71.1% of the tagging sample during the early run, respectively, and 12.3% and 64.5% during the late run (Table 4). Age 1.4 female chinook salmon were the most abundant sex-age group in both the early run (39.9%) and the late run (39.9%) samples.

The age compositions for males and females were significantly different in all 2-week periods (Table 5) with ages 1.2 and 1.3 represented in higher numbers for males (Appendix A1). No age 1.2 females were taken during the early run,

Table 3. Results of Kolmogorov-Smirnov test comparing length
          distributions of chinook salmon in the Kenai River 1989.

Comparison	D	n_1	n_2	p-value[a]
Early vs. late release	0.18	1,113	875	0.0001
Early release vs. tag fishery recovery	0.24	1,113	66	0.0015
Late release vs. tag fishery recovery	0.10	875	52	0.65
Early release vs. creel recovery	0.09	1,113	31	0.95
Late release vs creel recovery	0.26	875	12	0.40
Late release vs August recovery	0.17	875	21	0.62
Early release vs creel sample	0.09	1,113	233	0.08
Late release vs creel sample	0.17	875	107	0.01
Late release vs August sample	0.07	875	540	0.06

[a] Tests rejected if $p < 0.05$.
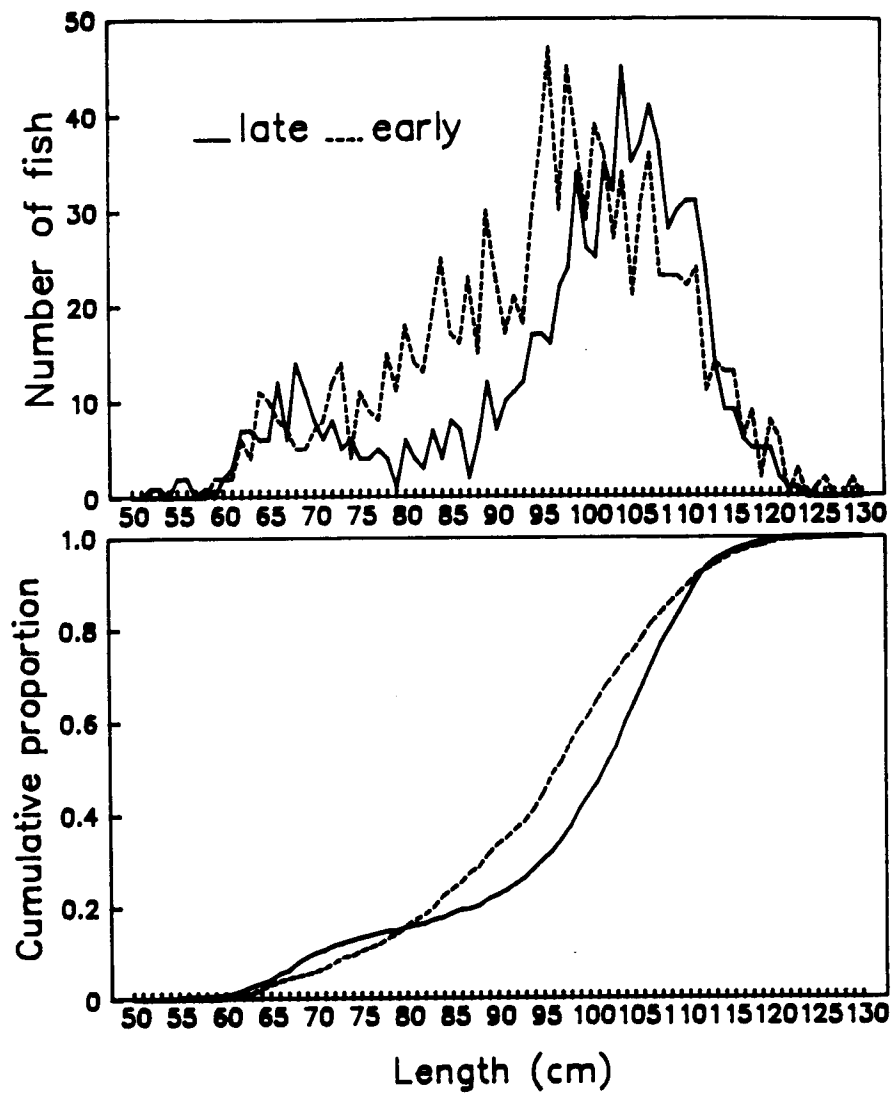
Figure 4. Length distributions for tagged fish released in early and late
tagging fisheries in Kenai River, 1989.
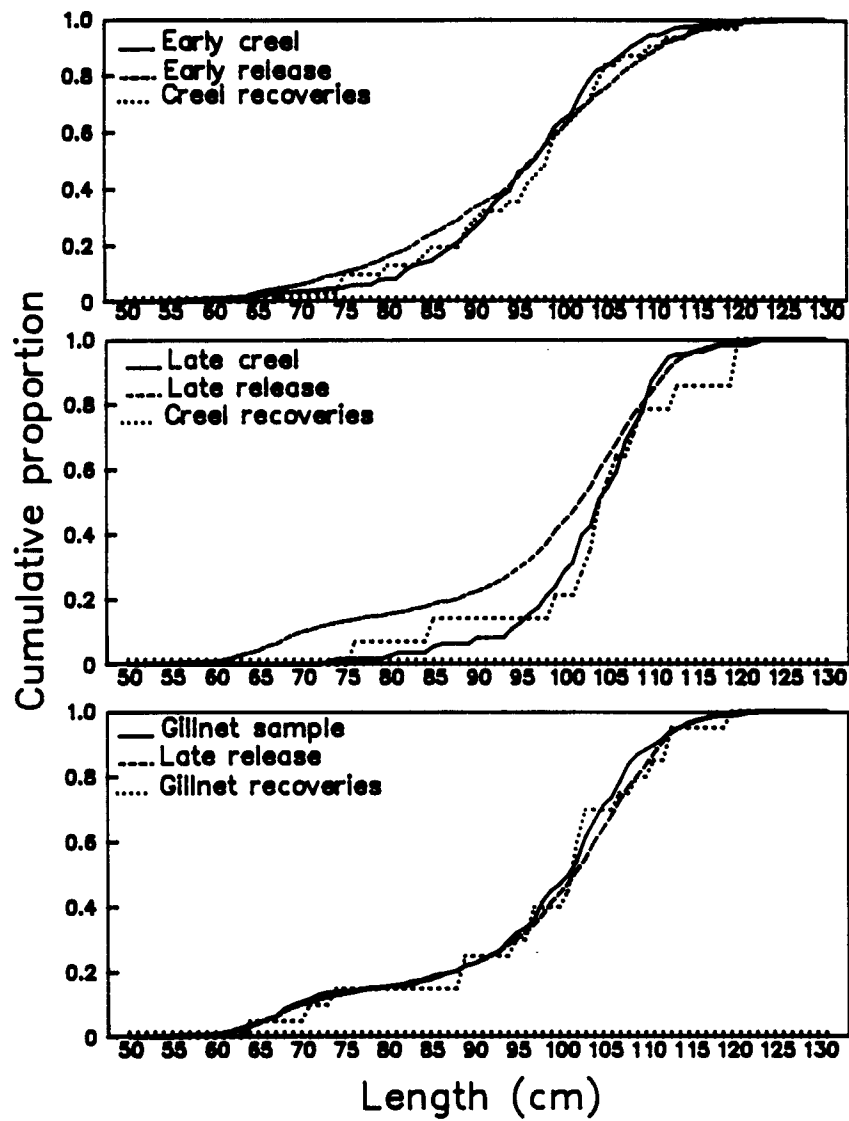
Figure 5. Length distributions for tagging and recovery gill net fisheries and recaptures in sport fishery for Kenai River 1989.

Table 4. Age group composition of early and late run chinook salmon
caught by drift gill nets in the Kenai River, 1989.

			Age Group					
Component	Sex	Statistic	1.2	1.3	1.4	1.5	Other	TOTAL
EARLY RUN	Female	Sample Size		41	271	26		338
5/17 - 6/30		% of Sample		6.0	39.9	3.8		49.8
		SE		0.91	1.88	0.74		1.92
	Male	Sample Size	27	61	212	38	3[a]	341
		% of Sample	4.0	9.0	31.2	5.6	0.4	50.2
		SE	0.75	1.10	1.78	0.88	0.24	1.92
	Combined	Sample Size	27	102	483	64	3	679
		% of Sample	4.0	15.0	71.1	9.4	0.4	100.0
		SE	0.75	1.37	1.74	1.12	0.24	
LATE RUN	Female	Sample Size	14	40	244	46	5[b]	349
7/01 - 8/07		% of Sample	2.3	6.5	39.9	7.5	0.8	57.0
		SE	0.60	1.00	1.98	1.07	0.36	2.00
	Male	Sample Size	48	35	151	28	1	263
		% of Sample	7.8	5.7	24.7	4.6	0.2	43.0
		SE	1.09	0.94	1.74	0.85	0.16	2.00
	Combined	Sample Size	62	75	395	74	6	612
		% of Sample	10.1	12.3	64.5	12.1	0.98	100.0
		SE	1.22	1.33	1.94	1.32	0.40	
SEASON TOTAL	Female	Sample Size	14	81	515	72	5[b]	687
5/20 - 8/07		% of Sample	1.1	6.3	39.9	5.6	0.4	53.2
		SE	0.29	0.68	1.36	0.64	0.18	1.39
	Male	Sample Size	75	96	363	66	4	604
		% of Sample	5.8	7.4	28.1	5.1	0.3	46.8
		SE	0.65	0.73	1.25	0.61	0.15	1.39
	Combined	Sample Size	89	177	878	138	9	1,291
		% of Sample	6.9	13.7	68.0	10.7	0.7	100.0
		SE	0.71	0.96	1.30	0.86	0.23	

[a] Age groups 2.4 and 2.5 combined.
[b] Age groups 1.1, 1.6, 2.1, 2.3, and 3.1 combined.

Table 5. Results of chi-square tests comparing age-compositions for Kenai chinook salmon 1989.

Hypothesis	v^2	df	p-value[a]
Age composition is the same for males and females within periods:			
Early Period 1	3.5	3	0.32
Period 2	26.6	3	<0.001
Period 3	15.2	3	0.002
Late Period 1	11.7	3	0.008
Period 2	8.8	3	0.03
Period 3	17.6	3	0.001
Age composition did not change between periods			
Early Males	18.5	6	0.005
Females	3.13	4	0.536
Late Males	1.55	6	0.956
Females	8.72	6	0.190
Age composition is the same for both runs			
Males	15.3	3	0.002
Females	20.9	3	<0.001

[a] Tests rejected if $p \leq 0.05$

but 4% of the females taken in the late run were age 1.2. Similarly, the percent of age 1.2 males increased in the tagging fishery from the early to the late runs.

Females represented 53% of all tagged fish, 50% of the early run and 57% of the late run sample (Table 4).

The mean lengths by age and sex of the chinook salmon sampled during the late run were larger than those sampled during the early run (Table 6). Age 1.3 females were larger than age 1.3 males in all periods except the last 2 weeks of July, while age 1.4 and age 1.5 males were larger than age 1.4 and age 1.5 females in every time period (Appendix A2).

Spawning Escapement

Spawning ground samples were taken over 3 days, all in lower river reaches (up to Soldotna, RKM 56). Age compositions of the samples were represented equally by 1.3 and 1.4 age class fish (Table 7). Mean lengths of the carcass samples were similar to those collected from the tagged sample in that age 1.3 females were larger than age 1.3 males, and both age 1.4 and 1.5 males were larger than their female counterparts (Table 8). Comparisons between the spawning fish utilizing the upper reaches of the river and those fish spawning in the lower stretches of the river were not possible as flood level conditions prevented sampling the upper river.

Tag Releases

During the period 17 May through 7 August, 1,991 chinook salmon were tagged (Table 9). Twenty-one chinook salmon tagged in the Kenai River were eventually recovered outside of the system: 2 in the Kasilof River and 19 in the commercial set net fishery (Table 9). Tagged chinook salmon caught by the commercial fisheries in the marine waters outside of the Kenai River should not necessarily be interpreted as all being from systems other than the Kenai River. This group of fish could include fish from the Kenai River which backed out of the river and were taken in the commercial fisheries, as well as salmon from other systems which strayed into the Kenai River.

Thirteen chinook salmon with missing adipose finclips were captured during tagging. Heads were removed from these fish and stored for processing. Only 10 of these 13 fish were found to have tags. Seven of these ten tags were from fish tagged in the Kenai system: 5 tagged in the mainstem and 2 in the Killey River, and there were 3 strays from the Crooked Creek hatchery.

Tag Recoveries

During the period 17 May through 30 July, 1,531 chinook salmon were examined for tags in the creel survey and 44 tags were recovered (Table 10 and Appendix A3). The majority of fish were recovered by the roving creel survey in the downstream area where 812 chinook salmon were examined and 27 tags recovered, with 670 fish examined during interviews at the access sites and 17 tags recovered. In the upstream survey, 49 fish were examined but no tags

Table 6. Mean length (mm), by sex and age group, of early and late run chinook salmon caught by drift gill nets in the Kenai River, 1989.

Component	Sex	Statistic	Age Group						TOTAL
			1.2	1.3	1.4	1.5	2.4	2.5	
EARLY RUN	Female	Sample Size		41	271	26			338
5/17 - 6/30		Mean Length		805	965	1,044			952
		SE		9.59	4.64	13.15			5.13
	Male	Sample Size	27	61	212	38	1	2	341
		Mean Length	650	773	1,041	1,142	730	965	972
		SE	5.27	10.51	5.82	12.23		55.00	9.07
	Combined	Sample Size	27	102	483	64	1	2	679
		Mean Length	650	786	998	1,102	730	965	962
		SE	5.27	7.50	4.02	10.81		55.00	5.23

Component	Sex	Statistic	Age Group											TOTAL
			1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.3	2.4	2.5	3.1	
LATE RUN	Female	Sample Size	1	14	40	267	50	1	1	1			1	376
7/01 - 8/07		Mean Length	990	662	846	1,012	1,055	1,030	870	950			930	986
		SE		10.39	12.55	3.6	7.70							5.3
	Male	Sample Size		52	36	167	32	1						288
		Mean Length		642	807	1,067	1,133	1,150						965
		SE		6.6	14.6	5.5	8.1							11.1
	Combined	Sample Size	1	66	76	434	82	2	1	1			1	664
		Mean Length	990	646	828	1,032	1,084	1,090	870	950			930	977
		SE		5.7	9.7	3.30	7.0	60.00						5.7

- Continued -

Table 6.   (Page 2 of 2).

Component	Sex	Statistic	1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.3	2.4	2.5	3.1	TOTAL
							Age Group							
SEASON TOTAL	Female	Sample Size	1	14	81	538	76	1	1	1			1	714
5/17 - 8/07		Mean Length	990	662	825	989	1,050	1,030	870	950			930	970
		SE		10.4	8.2	3.1	6.7							3.8
	Male	Sample Size		79	97	379	70	1			1	2		629
		Mean Length		643	785	1,052	1,138	1,150			730	965		968
		SE		4.87	8.70	4.1	7.6					55.00		7.1
	Combined	Sample Size	1	94	178	919	146	2	1	1	1	2	1	1,346
		Mean Length	990	647	804	1,015	1,092	1,090	870	950	730	965	930	969
		SE		4.3	6.20	2.7	6.2	60.00				55.00		3.9

Table 7. Estimated age composition of chinook salmon sampled during surveys of spawning grounds on the mainstem of the Kenai River, 1989.

Dates	Sex	Statistic	Age Group				Total
			1.2	1.3	1.4	1.5	
9/20-9/21 (Lower Reach)	Female	Percent		32.2	15.3	5.1	52.5
		Standard error		6.14	4.72	2.88	6.56
		Sample size		19	9	3	
	Male	Percent	1.7	10.2	27.1	8.5	47.5
		Standard error	1.69	3.97	5.84	3.66	6.56
		Sample size	1	6	16	5	
		Combined percent	1.7	42.4	42.4	13.6	100.0
		Standard error	1.69	6.49	6.49	4.50	
		Sample size	1	25	25	8	

Table 8. Mean length (mm), by sex and age group, of chinook salmon
sampled during surveys of spawning grounds on the mainstem
of the Kenai River, 1989.

Dates	Sex	Statistic	Age Group			
			1.2	1.3	1.4	1.5
9/20 - 9/21	Female	Mean length		992	1,019	1,063
		Sample size		19	9	3
		Standard error		1.07	1.39	2.60
	Male	Mean length	690	988	1,083	1,108
		Sample size	1	6	16	5
		Standard error		2.17	2.19	1.77
	Combined	Mean length	690	991	1,060	1,091
		Sample size	1	25	25	8
		Standard error		0.94	1.60	1.59

Table 9. Tag releases by day and recoveries from each daily release for chinook salmon in the Kenai River, 1989.

Date of Release	Number Tagged	Out-of-[a] System	Adipose[b] Clips	Number[c] Recovered in Creel	Number[d] Recovered in Gill Net
17-May	5				
18-May	7				
19-May	4				
20-May	10				
21-May	4				
22-May	17				
23-May	21				
24-May	21				
25-May	12		1 (CC)	2	
26-May	12				
27-May	22	1 (CA)			
28-May	25			3	
29-May	20				
30-May	7			1	
31-May	25			1	
01-June	34				
02-June	18				
03-June	23			2	
Subtotal	287	1	1	9	
04-June	19				
05-June	41		1 (KR)		
06-June	77		1 (KR) 1 (CC)	2	
07-June	46			1	
08-June	62				
09-June	29			2	
10-June	31				
11-June	16			1	
12-June	13				
13-June	26			1	
14-June	33			1	
Subtotal	393		3	8	
15-June	25			1	
16-June	12			1	
17-June	19			2	
18-June	19			1	
19-June	15				
20-June	31			2	
21-June	29				
22-June	48			1	
23-June	36				
24-June	33			1	
25-June	26			2	1
26-June	29				1
27-June	34			2	
28-June	32				
29-June	28			1	1
30-June	19				1
Subtotal	435			14	4

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Table 9. (Page 2 of 3).

Date of Release	Number Tagged	Out-of-[a] System	Adipose[b] Clips	Number[c] Recovered in Creel	Number[d] Recovered in Gill Net
01-July	26				
02-July	27			2	
03-July	10	1 (CS)			
04-July	21		1 (KM)[e]	1	
05-July	30				
06-July	32				
07-July	25	1 (CS)			
08-July	25				
09-July	48		1 (KM)		1
10-July	44	2 (CS) 1 (K)			1
11-July	76				
12-July	97		2 (KM)[e]	1	3
13-July	46				1
14-July	58	1 (K)			
15-July	22	1 (CS)		1	
Subtotal	542	7	4	5	6
16-July	23			1[f]	
17-July	25	1 (CS)			1
18-July	38	1 (CS)		2	1
19-July	20				
20-July	26		1 (KM)		
21-July	18	1 (CS)	1 (KM)[e]		1
22-July	10			1	
23-July	17	1 (CS)			1
24-July	9	2 (CS)			
25-July	25	1 (CS)		1	
26-July	28			1	4
27-July	25	1 (CS)		2	2
Subtotal	264	8	2	8	10
TOTAL	1,921	16	10	44	20

- Continued -

Table 9. (Page 3 of 3).

Date of Release	Number Tagged	Out-of-[a] System	Adipose[b] Clips	Number[c] Recovered in Creel	Number[d] Recovered in Gill Net
28-July	9				
29-July	9	1 (CS)			1
30-July	10	2 (CS)			
31-July	8	1 (CS)			
01-August	14				
02-August	6				2
03-August	4	1 (CS)			
04-August	5				
05-August					
06-August					
07-August	5		1 (CC) 1 (KM)		
08-August					
09-August					
10-August					
11-August					
Subtotal	70	5	2	0	3
GRAND TOTAL[g]	1,991	21	12	44	23

[a] Tags recovered outside the Kenai River:
   CA = recovered in the sport fishery at Deep Creek,
   CD = recovered in the commercial drift gill net fishery,
   CS = recovered in the commercial set net fishery,
   K = recovered in the Kasilof River.

[b] Number of fish with coded-wire tags captured
   by the tagging crews with healed-over or missing adipose fins
   (not freshly clipped).
   KM = tag origin from mainstem Kenai River,
   KR = tag origin from the Killey River,
   CC = tag origin from the Crooked Creek hatchery.

[c] Tag recoveries from both roving creel and access-site creel census.

[d] Tag recoveries from the August gill net recovery effort.

[e] A total of 4 adipose clipped fish were recovered on these dates
   of which only 2 were found to have tags. Due to an error in the
   tag log, it is not known which fish of the four contained the tags.

[f] Tags recovered without recording the tag number but whose
   release stratum is known from the color of the tag.

[g] Total for the data included in the tagging estimate.

Table 10. Recoveries of tagged chinook salmon by the roving and access-site creel surveys and the gill net recovery effort in the Kenai River, 1989.

| | ROVING | | | | | | ACCESS-SITE | | GILL NET-FISHERY | |
| | Number Examined | | | Number Recaptured | | | Number | Number | Number | Number |
Date	Dwnstr	Upstr	Total	Dwnstr	Upstr	Total	Examined	Recap.	Examined	Recap.
16-May	0	0	0	0	0	0	1	0	0	0
17-May	4	0	4	0	0	0	1	0	0	0
18-May	7	0	7	0	0	0	1	0	0	0
19-May	5	0	5	0	0	0	2	0	0	0
20-May	2	0	2	0	0	0	2	0	0	0
21-May	0	0	0	0	0	0	1	0	0	0
22-May	0	0	0	0	0	0	0	0	0	0
23-May	0	0	0	0	0	0	2	0	0	0
24-May	0	0	0	0	0	0	5	0	0	0
25-May	8	0	8	2	0	2	0	0	0	0
26-May	3	0	3	0	0	0	1	0	0	0
27-May	8	0	8	0	0	0	0	0	0	0
28-May	12	0	12	1	0	1	5	2	0	0
29-May	13	0	13	0	0	0	0	0	0	0
30-May	9	0	9	1	0	1	1	0	0	0
31-May	7	0	7	1	0	1	0	0	0	0
01-June	0	0	0	0	0	0	0	0	0	0
02-June	14	0	14	0	0	0	0	0	0	0
03-June	24	0	24	1	0	1	32	1	0	0
04-June	11	0	11	0	0	0	10	0	0	0
05-June	0	0	0	0	0	0	0	0	0	0
06-June	17	0	17	2	0	2	6	0	0	0
07-June	31	0	31	1	0	1	22	0	0	0
08-June	12	0	12	0	0	0	18	0	0	0
09-June	15	0	15	1	0	1	17	1	0	0
10-June	17	0	17	0	0	0	4	0	0	0

- Continued -

Table 10. (Page 2 of 4).

| | ROVING | | | | | | ACCESS-SITE | | GILLNET-FISHERY | |
| | Number Examined | | | Number Recaptured | | | Number | Number | Number | Number |
Date	Dwnstr	Upstr	Total	Dwnstr	Upstr	Total	Examined	Recap.	Examined	Recap.
11-June	5	0	5	1	0	1	12	0	0	0
12-June	0	0	0	0	0	0	0	0	0	0
13-June	22	0	22	1	0	1	5	0	0	0
14-June	9	0	9	1	0	1	15	0	0	0
15-June	6	0	6	1	0	1	3	0	0	0
16-June	12	0	12	1	0	1	5	0	0	0
17-June	7	1	8	1	0	1	3	1	0	0
18-June	5	0	5	1	0	1	10	0	0	0
19-June	0	0	0	0	0	0	0	0	0	0
20-June	2	1	3	0	0	0	36	2	0	0
21-June	22	0	22	0	0	0	21	0	0	0
22-June	15	1	16	1	0	1	2	0	0	0
23-June	1	0	1	0	0	0	10	0	0	0
24-June	4	3	7	0	0	0	14	1	0	0
25-June	6	0	6	1	0	1	14	1	0	0
26-June	0	0	0	0	0	0	0	0	0	0
27-June	2	0	2	0	0	0	24	2	0	0
28-June	7	0	7	0	0	0	9	0	0	0
29-June	5	1	6	0	0	0	7	1	0	0
30-June	11	1	12	0	0	0	0	0	0	0
01-July	12	4	16	0	0	0	5	0	0	0
02-July	12	0	12	2	0	2	3	0	0	0
03-July	0	0	0	0	0	0	0	0	0	0
04-July	14	0	14	0	0	0	9	1	0	0
05-July	7	2	9	0	0	0	7	0	0	0
06-July	14	2	16	0	0	0	17	0	0	0
07-July	7	0	7	0	0	0	14	0	0	0

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Table 10. (Page 3 of 4).

Date	ROVING Number Examined Dwnstr	Upstr	Total	Number Recaptured Dwnstr	Upstr	Total	ACCESS-SITE Number Examined	Number Recap.	GILLNET-FISHERY Number Examined	Number Recap.
08-July	8	2	10	0	0	0	8	0	0	0
09-July	17	0	17	0	0	0	17	0	0	0
10-July	0	0	0	0	0	0	0	0	0	0
11-July	19	0	19	0	0	0	38	0	0	0
12-July	25	4	29	1	0	1	21	0	0	0
13-July	14	0	14	0	0	0	16	0	0	0
14-July	9	0	9	0	0	0	2	0	0	0
15-July	3	8	11	0	0	0	1	1	0	0
16-July	4	4	8	1[a]	0	1	2	0	0	0
17-July	0	0	0	0	0	0	0	0	0	0
18-July	14	6	20	1	0	1	23	1	0	0
19-July	15	1	16	0	0	0	27	0	0	0
20-July	21	0	21	0	0	0	5	0	0	0
21-July	10	2	12	0	0	0	8	0	0	0
22-July	30	3	33	1	0	1	9	0	0	0
23-July	15	0	15	0	0	0	4	0	0	0
24-July	0	0	0	0	0	0	0	0	0	0
25-July	26	1	27	0	0	0	23	1	0	0
26-July	47	0	47	0	0	0	20	1	0	0
27-July	42	0	42	2	0	2	39	0	0	0
28-July	30	0	30	0	0	0	27	0	0	0
29-July	13	0	13	0	0	0	1	0	0	0
30-July	24	2	26	0	0	0	3	0	0	0
31-July	0	0	0	0	0	0	0	0	27	2
01-August	0	0	0	0	0	0	0	0	30	2
02-August	0	0	0	0	0	0	0	0	37	3
03-August	0	0	0	0	0	0	0	0	47	3

- Continued -

Table 10. (Page 4 of 4).

| | ROVING | | | | | | ACCESS-SITE | | GILLNET-FISHERY | |
| | Number Examined | | | Number Recaptured | | | Number | Number | Number | Number |
Date	Dwnstr	Upstr	Total	Dwnstr	Upstr	Total	Examined	Recap.	Examined	Recap.
04-August	0	0	0	0	0	0	0	0	42	2
05-August	0	0	0	0	0	0	0	0	64	4
06-August	0	0	0	0	0	0	0	0	51	1
07-August	0	0	0	0	0	0	0	0	38	2
08-August	0	0	0	0	0	0	0	0	52	1
09-August	0	0	0	0	0	0	0	0	38	0
10-August	0	0	0	0	0	0	0	0	45	1
11-August	0	0	0	0	0	0	0	0	58	3
TOTAL	812	49	861	27	0	27	670	17	529	23

[a] Tag recovered without recording the tag number but whose release stratum is known from the color of the tag.

recovered. During the August gill net recovery efforts, 529 chinook salmon were captured and 23 tags were recaptured.

Abundance Estimate

A summary of tag release and recovery data by bimonthly time periods shows that the percent recovery by release period ranges from 2.2% to 5.7%, and the percent tagged in the recovery samples from 1.5% to 7.0% (Table 11).

The temporal strata were established so that the abundance of the May and June components of the early-run could be estimated separately from the late run. A chi-square test comparing the percent recovered by 2-week periods was not significant ($\chi^2 = 8.04$, df = 5 p > 0.1), but a comparison of tag ratios by recovery periods was significant ($\chi^2 = 16.4$, df = 5, p < 0.01). The comparison of tag ratios by recovery period within the early run was not significant ($\chi^2 = 2.6$, df = 2, p > 0.25), but significant within the late run ($\chi^2 = 9.2$, df = 2, p < 0.01), where the percentages tagged in the recovery samples were 1.5% and 1.6% in the first and second periods, but 4.2% in the last (Table 11).

Three strata were defined for the purposes of estimating abundance, the first covering the early run from 20 May to 30 June, the second from 1 July to 25 July, and the third from 26 July to 7 August (Table 12). This stratification met the criterion that estimates for the early and late runs were separated at 1 July, and separates the late run into two strata with significantly different tagged-to-untagged ratios.

The tag releases and recovery samples were also stratified into two size groups, salmon under 75 cm and those over 75 cm. All fish tagged and released were measured as were all salmon taken in the August gill net recovery fishery. However, only a subsample of the chinook salmon examined in the creel survey were measured. The proportions in these subsamples falling into each of the size groups were used to allocate the total recovery creel samples into the two groups. No fish under 75 cm were seen in the creel samples in July, but 8.1% of the fish measured in May and June were under 75 cm.

Chi-square tests comparing the frequency of tags recovered by release strata were not significant (Table 12) but the test comparing the tagged to untagged ratios by recovery strata (Table 12) was significant (p < 0.005). These tests were only performed for the larger size group as the sample sizes were too small for chinook salmon under 75 cm. A Petersen estimate of abundance was not appropriate and the methods of Darroch (1961) were used.

A total of 80,532 (SE = 17,133) chinook salmon were estimated to enter the Kenai River from 20 May through 7 August (Table 13). The early run estimate was 23,253 (SE = 6,914) salmon of which 5,885 (SE = 5,910) were under 75 cm and 17,368 (SE = 3,588) over 75 cm. A total of 57,279 (SE = 15,676) late run chinook salmon were estimated to enter the river from 1 July to 7 August, of which 2,223 (SE = 1,705) were under 75 cm and 55,056 (SE = 16,636) over 75 cm.

The estimate of chinook salmon under 75 cm is a minimum. This is due to both the selectivity of the tagging gear for larger fish during the early run and

Table 11. Tag recovery summary by 2-week periods for chinook salmon in the Kenai River, 1989.

Release Period		Recovery Period						Recovery in Creel	Total Recovery in Gill net and Creel	Total Released	Percent Recovered in Creel	Percent Recovered in Gill nets	Total Percent Recovered in Gill nets and Creel
		1	2	3	4	5	6[a]						
5/17-5/31	1	7	4	1				12	12	212	5.7		5.7
6/01-6/15	2		7	4				11	11	493	2.2		2.2
6/16-6/30	3			8	1		5	9	14	410	2.2	1.0	3.2
7/01-7/15	4				4	4	6	9	14	542	1.7	1.1	2.8
7/16-7/27	5					3	9	3	12	264	1.1	3.8	4.9
7/28-8/11	6						3		3	70		4.3	4.3
Tagged		7	11	13	5	8	23	44	67	1,991	2.3	1.6	3.4
Examined		100	328	261	341	501	552	1,531	2,083				
Untagged		93	317	248	336	493	529	1,487	2,016				
% Tagged		7.0	3.5	5.2	1.5	1.6	4.2	3.0	3.3				

[a] Tag recoveries during the August gill net recovery effort.

Table 12. Summary of tag releases and tag recoveries, by stratum, for
          chinook salmon in the Kenai River, 1989.

Stratum	Tag Recoveries 1	2	Number Recovered	Number Released	Percent Recovered
Under 75 cm:					
20 May-30 June	1	0	1	107	0.9
1 July-7 August	0	4	4	114	3.5
Marked	1	4			
Examined	56	81			
Percent examined	1.8	3.7			

Stratum	Tag Recoveries 1	2	3	Number Recovered	Number Released	Percent Recovered
Over 75 cm:						
20 May-30 June	30	1	5	36	1,007	3.5
1 July-24 July	0	7	10	17	628	1.5
25 July-7 August	0	0	9	9	134	6.7
Marked	30	8	24			
Examined	633	594	1,027			
Percent examined	4.7	1.3	2.2			

Table 13. Estimate of abundance for 1989 Kenai River chinook salmon.

	Run	Abundance	Variance	SE	% RP[a]
TAGGING ESTIMATE					
Under 75 cm					
	Early	5,885	34,933,360	5,910	197
	Late	2,223	1,253,216	1,119	99
Over 75 cm					
	1-Early	17,368	12,874,046	3,588	40
	2-Late	40,108	259,754,144	15,676	79
	3-Late	14,948	23,368,478	4,834	63
	Late	55,056	244,499,218	15,636	56
All sizes					
	Early	23,253	47,807,406	6,914	58
	Late	57,279	245,752,434	15,676	54
	Total	80,532	293,559,840	17,133	42
SONAR ESTIMATE					
	Early	17,992			
	Late	29,045			
	Total	47,037			

[a] Relative size of half of the 95% confidence interval.

to the selectivity in the harvest for larger fish, so the estimate represents a minimum estimate of abundance for chinook salmon entering the Kenai River. This estimate also includes all fish which are vulnerable to the tagging fishery and therefore includes those that are truly of Kenai River origin as well as any salmon which have "strayed" into the river from non-Kenai systems. Assuming the proportion of "strays" tagged is the same as for the total immigration (= strays + Kenai salmon), then the abundance estimate is an estimate of this total immigration, not just Kenai River chinook salmon.

The size of the 95% confidence interval relative to the estimate (relative precision) for the total run was 42% in 1989, with the relative precision at 58% for the early run and 54% for the late run (Table 13).

Bootstrap estimates of abundance were only made for the larger size group, as sample sizes were too small for salmon under 75 cm. These estimates of abundance (Figure 6) were consistently higher in all strata compared to the original tag estimate. This bias was smallest (9%) for the estimate of the early run. However, in the estimates of abundance for the late run strata, the bias was 19% and 12% when abundance was higher.

The imprecision of the estimate of late run abundance and the sampling bias estimated by the bootstrap are due to the small numbers of tags recovered. During the late run in July, the estimated abundance is high, but the number of tags released relative to the estimated abundance is low. Combining all sizes and setting sampling rates in July equal to those during the early run (Table 14) both for tagging and examining fish for tags, the precision is improved in all late run stratum and the overall relative precision would be 17%. If the rate of fish examined alone is increased during the July stratum, then the precision achieved for the total run would be 26%, which is the goal set by the objective criteria for this project.

Catch and Effort Indices:

The linear correlation coefficients for the catch-effort statistics with the estimated mean abundance of chinook salmon per day decreased for all statistics when the 1986-1989 data are combined (Table 15). Examination of the scatterplots for these statistics show that in some cases the 1989 catch-effort statistics did not even follow the general trend of previous years' data (Appendix B1). Only three statistics had coefficients over 0.60, catch per set (CAT/SET), the percent of effort in net-minutes with catch greater than 0 (%EFF>0), and catch per crewday (CAT/CD).

The power model for the statistic CAT/SET had the smallest confidence intervals for the estimated parameters (Table 16), and the smallest variance estimated using the Monte Carlo simulation method. This model was selected to estimate the number of chinook salmon entering the Kenai River from 29 July to 7 August. The nonlinear, least-squares parameter estimates for the power model resulted in the following model (Figure 7):

$$\text{Abundance/day} = 1,073.5 \ (\text{CAT/SET})^{3.1} \qquad\qquad [7]$$
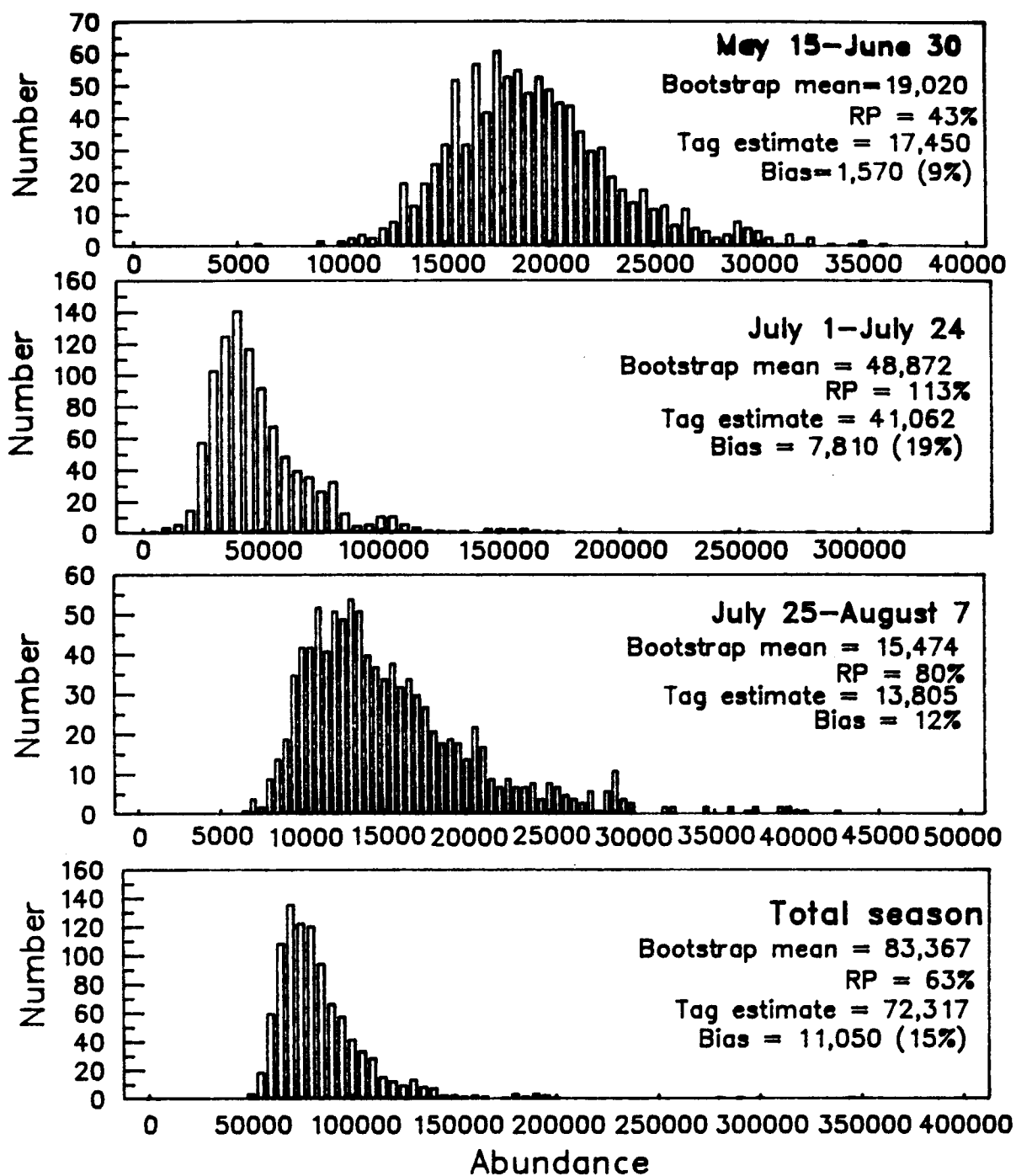
Figure 6. Distribution of 1,000 bootstrap estimates of abundance by strata in the Kenai River tagging experiment 1989.

Table 14. Evaluation of sample sizes for tagging experiment for chinook
           salmon in the Kenai River, 1989.

A. Percent of total population tagged and examined for tags increased
    in July.

| | Tag Recoveries | | | Number | Estimated | |
Stratum[a]	1	2	3	Released	Abundance	Precision
Tag release:						
1 5/20 - 6/30	31	3	5	1,116	20,703	37%
2 7/1 - 7/24	0	69	35	2,443	48,988	25%
3 7/25 - 8/7	0	0	54	534	10,956	26%
Examined	689	1,612	1,108	Total	80,648	17%

B. Examination rate increased in July.

| | Tag Recoveries | | | Number | Estimated | |
Stratum[a]	1	2	3	Released	Abundance	Precision
Tag release:						
1 5/20 - 6/30	31	3	5	1,116	21,709	37%
2 7/1 - 7/24	0	22	11	767	48,220	43%
3 7/25 - 8/7	0	0	10	99	10,969	59%
Examined	689	1,612	1,108	Total	80,899	26%

[a] Tag recovery and tag release strata are the same time periods.

Table 15.   Correlations between the estimates of mean abundance of
            chinook salmon per day for a stratum and the effort/catch
            statistics computed using charts from 1986, 1987, 1988,
            and 1989, separately and combined.

	Statistic[a]	1986	1987	1988	1989
1.	TOTSETS	0.897	0.927	0.398	0.298
2.	TOTEFF	-0.737	0.838	0.182	0.111
3.	TOTCAT	0.876	0.943	0.499	0.426
4.	MNDUR	-0.763	-0.891	-0.639	-0.449
5.	MNCAT	0.753	0.563	0.690	0.611
6.	CPUE	0.859	0.847	0.748	0.580
7.	TOTEFF=0	-0.777	0.647	-0.169	-0.099
8.	MNDUR=0	-0.875	-0.607	-0.711	-0.531
9.	%EFF>0	0.860	0.468	0.742	0.663
10.	SETS>0	0.869	0.939	0.450	0.371
11.	%SETS>0	0.690	0.788	0.641	0.567
12.	MNDUR>0	-0.728	-0.925	-0.595	-0.359
13.	EFF/D	-0.720	0.317	-0.407	-0.310
14.	CAT/CD	0.889	0.980	0.806	0.629
15.	SETS/CD	0.911	0.983	0.788	0.557
16.	SETS>0/CD	0.866	0.996	0.791	0.594

[a] See Table 1 for definitions of these statistics.

Table 16. Models relating catch-effort statistics to abundance per day for Kenai River chinook salmon 1989.

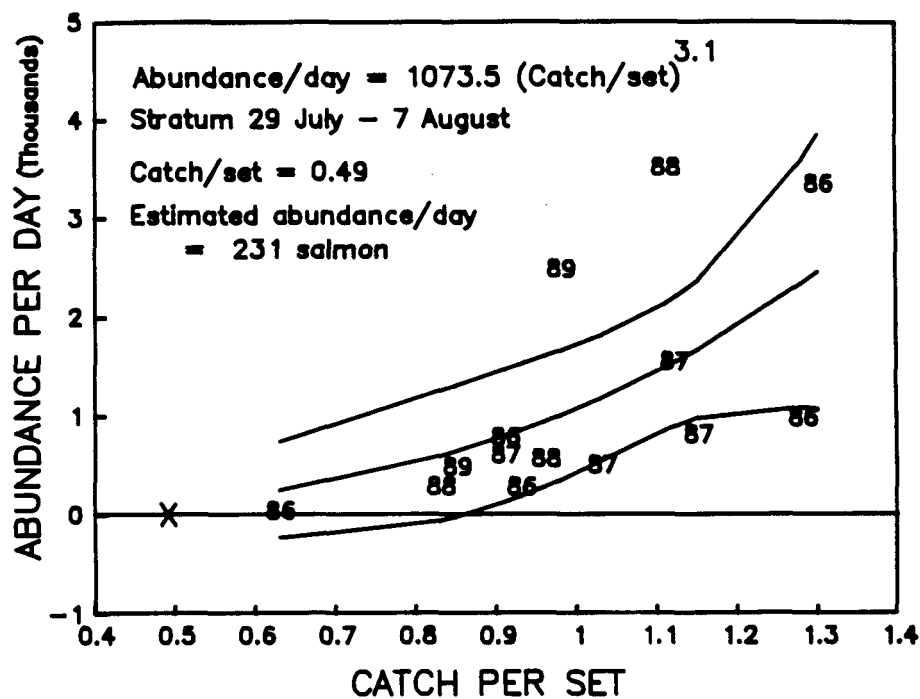| Model	Statistic	MSE	RP(bo)[a]	RP(b_1)
Linear	CAT/SET	878,783	54%	37%
	%EFF>0	785,972	44%	32%
	CAT/CD	848,276	100%	36%
Exponential	CAT/SET	914,690	151%	45%
	%EFF>0	723,499	172%	34%
	CAT/CD	824,292	72%	351%
Power	CAT/SET	896,942	27%	46%
	%EFF>0	722,399	53%	36%
	CAT/CD	832,591	209%	38%

[a] RP = (standard error)/parameter estimate

Figure 7. Catch statistic (CAT/SET) versus the estimated mean abundance of chinook salmon per day by temporal strata, 1986-1989. This model was used to estimate the abundance for stratum 3 (28 July to 7 August) in 1989.

For stratum 3, CAT/SET = 0.49, resulting in an estimate of mean abundance of 231 chinook salmon per day for stratum 3. The empirical estimate of the standard error (SE) for this estimate from the Monte Carlo simulation is 348. For the 8 days from 31 July through 7 August, this gives an estimated total abundance of 1,848 chinook salmon with a standard error of 2,089 and a relative precision of 113%.

The estimate of abundance using only recoveries from the creel survey is 23,027 salmon for the early run and 70,300 for the late run during July (Table 17). The total late run is 72,148 and the season's total is 93,253 chinook salmon. The estimate and its precision (38%) for the early run has not changed substantially, however, the estimate of abundance for the late run has increased and the precision is 63%, and the total run has a precision of 57% compared to 42% (Table 12) for the estimate using only tag recoveries.

This method performed adequately in 1986 and 1987, however, in 1988 and particularly in 1989, the correlation between the catch/effort statistics and estimated abundance per day has decreased, and the estimates derived using this method have similarly become less precise.

DISCUSSION

In 1989, a total of 80,532 chinook salmon were estimated to have entered the Kenai River: 23,253 during the early run and 57,279 during the late run. In 1989, as in 1988, the tagging estimate was substantially higher than the sonar estimate (Table 13), but the sonar estimate did fall within the 95% confidence interval (CI) of the tagging estimates for both runs. However, for the late run, this was only because the estimate was so imprecise. The difference between the two estimates represents 29% of the early run sonar estimate, 97% of the late run, and 71% of the total sonar estimate for 1989.

The quality of the estimate of abundance for Kenai River chinook salmon can be evaluated in two areas, precision and bias.

Precision of Tagging Estimate

The estimate of abundance in 1989 did not achieve the goal of a relative precision of ± 25% (α = 0.05). The relative precision of the tagging estimate of total abundance in 1989 (42%) was similar to 1988 but substantially higher than in 1987 (21%) and 1986 (27%). This was largely due to the imprecision of the estimate of abundance in July. In the first week of July, which was the peak of the late run according to the sonar estimates, the number of fish sampled in the tagging fishery and creel did not increase from previous weeks (Table 10). In order to improve precision, sample sizes would have to be increased during this period of high abundance.

Maximum resources were already being utilized both in the tagging effort and the recovery effort in the creel survey. So, in 1989, an upriver gill net fishery was undertaken in August with the objective of increasing the number of fish examined for tags, and of recovering tags after the fishery was closed on 31 July. The expectation was that precision would improve, which was in

Table 17. Numbers of chinook salmon estimated to enter the Kenai River during 1989 excluding recoveries from August recovery gill net fishery.

Stratum	Point Estimate	Standard Error[a]
Early Run:		
17 May - 30 June	23,027	4,081
Late Run:		
1 July - 30 July	70,300	20,965
31 July - 7 August	1,848	2,089
Total	71,342	23,054
Season's total	93,253	27,135

[a] Standard errors for the totals include covariance terms and are not simply the sum of the variances of the stratum estimates.

fact not the case in 1989. This was due to the unusually early migratory timing exhibited by the late run Kenai chinook salmon in 1989. The mean arrival date was 15 July in 1989, compared to 23 July and 22 July in 1987 and 1988, respectively, as estimated from daily sonar counts (McBride et al. 1989). Thus the majority of the run was past prior to August and the increased sampling was not as effective as hoped, although it did improve the precision compared to the estimate using tags recaptured during the creel survey and estimating the August abundance using catch-effort statistics. Based on historical performance, 10% to 25% of the run should arrive after 1 August compared to the 3% observed in 1989. In a year with high abundance during the late run, a tag recovery effort in August would be crucial in achieving the precision levels set as objective criteria.

Bias in Tagging Estimate

Sampling Bias:

The bootstrap estimates of abundance and variance show that the sampling bias increases as the number of tagged recoveries decreases. During the early run, bias is under 10% and the distribution of abundance estimates (Figure 6) has a normal distribution. During the late run, biases are as high as 19% and the distributions are skewed, due to the small number of tag recoveries. This is probably due to the saturation of the tagging gear, a smaller proportion of the incoming run is tagged, and tag ratios decrease in the population.

Size-selectivity:

In 1989, selection occurring in the fishery introduced bias in the abundance estimate, as the estimate of abundance of small chinook salmon was a minimum estimate. The tagging gear was selective for small fish during the early run, and in the creel survey during the late run no fish under 75 cm were sampled. Thus, only the estimate of salmon over 75 cm can be considered to represent abundance.

Non-Kenai Stocks:

As has been found in every year since the project's inception in 1985 (Conrad and Larson 1987, Conrad 1988, Carlon and Alexandersdottir 1989), small numbers of chinook salmon tagged in the lower Kenai River were recovered in other systems in 1989. The out-of-system recoveries in 1989 were from Deep Creek (1) and the Kasilof River (2). In previous years, tag recoveries have also occurred from the Susitna River (1 in 1985, 2 in 1986) and Deep Creek (1 in 1985). The estimate of abundance will include these non-Kenai River "strays", resulting in an over-estimate of the Kenai populations. The Kasilof River has been the largest source of out-of-system recoveries in previous years: 11 recoveries in 1985, 5 recoveries in 1986, and 3 recoveries in both 1987 and 1988. Because of the proximity of the Kasilof River to the Kenai River, it is assumed that more fish from this stock are present in the lower Kenai River than any other stock. In 1986, 676 chinook salmon from Crooked Creek hatchery were estimated to be present in the lower Kenai River from 17 May to 30 June from analysis of coded-wire tag data; Conrad and Larson (1987) concluded that this source of error was minimal since Kasilof fish were present in such small

numbers. In 1989, only 3 of 10 coded-wire tagged fish recovered in the Kenai River were from the Crooked Creek hatchery, while the remaining 7 were of Kenai origin.

Backing Out:

In addition to tagged and untagged non-Kenai stocks leaving the system, it is possible that tagged fish could back out of the Kenai River in response to the stress of handling. Those salmon that are of Kenai origin would be expected to return to the river, however, during the late run, these "back-outs" are once again vulnerable to the fisheries in Cook Inlet, particularly the set net fishery. Harvest of tagged fish before they could re-enter the river would bias the estimate of abundance of chinook salmon in the Kenai River, equal to the proportion of fish that backed out and did not return but were harvested. This type of behavior was observed in the 1989 radio-tag experiment during the late run, when 19 fish left the river after tagging, 9 were known to be taken in the set net fishery, 2 returned to the river, and 8 were never relocated (Bendock and Alexandersdottir 1990). If this "backing-out" behavior is a response to handling stress, and more tagged fish leave the Kenai River than untagged fish, then the result would be to bias the abundance estimate high, as the percent tagged falls in the river. However, whether this differential behavior occurs, and the extent to which it may be affecting our estimate of the late run abundance, cannot be evaluated.

Tag Loss and Tag Removal:

In 1989, one chinook salmon was observed with a tagging wound and no spaghetti tag attached during the creel surveys. In previous years, loss of tags by chinook salmon tagged by the gill net crews has been observed to be very small (less than 0.5%). There is no direct evidence of natural tag loss in 1989. It was discovered during the creel survey that one angler intentionally deceived the creel clerk concerning the fact that the chinook in possession was a tagged fish. Although this does violate the assumption that tags are not selectively removed from tagged fish, no more similar incidents have been reported so it is assumed that the overall effect upon the estimate is minimal.

Conclusions

The tag releases are not providing an estimate of abundance that meets the precision goals set in objective criteria. In addition, the probable biases found in the abundance estimates decrease the usefulness of the estimate for management. This is particularly true of the late run estimate, which basically suffers from all of the biases discussed above. During the early run, the sampling bias is minimal and tag release and recapture rates are higher than during the late run. Biases introduced by tagged fish backing-out and being vulnerable to marine fisheries only applies to the late run, and size selectivity in the harvest appears to be more of a problem during the late run than the early.

These problems have increased over the years of the project. In 1986 and 1987, precision levels achieved were reasonable, and no evidence was found of

size-bias. The increasing effort (Figure 2) in the sport-fishery for large chinook salmon in the Kenai River may be contributing to the problems as tagging crews and anglers compete for fish and space.

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APPENDIX A - TABLES

Appendix A1. Detailed release and recovery information for the 44 tags
              recovered from chinook salmon during creel surveys of the
              Kenai River, 1989.

Tag Number	Color	Sex	Length mm	Date Tagged	Date Recovered	Days Out	Recovery Source[a]	Mile Tagged	Mile Recovered
12282	ORANGE	M	1040	17-May	09-Jun	23	ASS	7.9	22.9
12392	ORANGE	M	750	21-May	07-Jun	17	DRS	8.0	16.0
12398	ORANGE	F	990	22-May	25-May	3	DRS	7.1	11.4
12509	ORANGE	F	1030	23-May	25-May	2	DRS	7.2	13.4
12508	ORANGE	F	970	23-May	28-May	5	ASS	7.2	15.0
12525	ORANGE	M	1040	24-May	28-May	4	ASS	7.1	10.4
12541	ORANGE	M	980	26-May	06-Jun	11	DRS	7.4	14.3
12548	ORANGE	F	850	27-May	28-May	1	DRS	7.3	11.4
12675	ORANGE	M	680	29-May	30-May	1	DRS	7.1	11.4
12566	ORANGE	F	960	30-May	31-May	1	DRS	6.7	11.4
12679	ORANGE	M	750	31-May	25-Jun	25	ASS	8.0	13.6
12573	ORANGE	M	1010	31-May	03-Jun	3	ASS	7.3	13.6
9370	GREEN	M	1120	01-Jun	18-Jun	17	DRS	8.0	14.3
9369	GREEN	F	990	01-Jun	06-Jun	5	DRS	8.0	14.1
9636	GREEN	F	960	01-Jun	11-Jun	10	DRS	7.2	11.4
9393	GREEN	M	840	02-Jun	03-Jun	1	DRS	7.3	11.4
9849	GREEN	F	900	06-Jun	14-Jun	8	DRS	7.1	12.3
9772	GREEN	F	910	06-Jun	16-Jun	10	DRS	7.0	11.4
9449	GREEN	F	940	06-Jun	20-Jun	14	ASS	7.0	18.1
9529	GREEN	F	800	07-Jun	09-Jun	2	DRS	9.2	10.1
9875	GREEN	M	1070	11-Jun	13-Jun	2	DRS	8.1	12.3
10258	GREEN	M	890	14-Jun	15-Jun	1	DRS	9.0	11.4
11264	WHITE	M	1100	15-Jun	17-Jun	2	ASS	8.2	14.1
11270	WHITE	M	1210	16-Jun	17-Jun	1	DRS	7.3	10.1
11268	WHITE	F	900	16-Jun	20-Jun	4	ASS	7.1	13.0
11296	WHITE	M	890	19-Jun	22-Jun	3	DRS	7.9	14.3

-Continued-

Tag Number	Color	Sex	Length mm	Date Tagged	Date Recovered	Days Out	Recovery Source[a]	Mile Tagged	Mile Recovered
11567	WHITE	M	1200	21-Jun	02-Jul	11	DRS	8.6	15.3
11662	WHITE	M	1150	23-Jun	27-Jun	4	ASS	8.6	13.6
11320	WHITE	F	1000	23-Jun	24-Jun	1	ASS	7.3	16.1
11352	WHITE	F	1050	24-Jun	27-Jun	3	ASS	9	13.6
11679	WHITE	F	1020	24-Jun	25-Jun	1	DRS	7.2	11.4
11622	WHITE	M	1050	28-Jun	29-Jun	1	ASS	8.6	10.1
*[b]	YELLOW			Jul	16-Jul		DRS		8.0
1835	YELLOW	M	1060	01-Jul	04-Jul	3	ASS	7.2	15.3
13200	YELLOW	M	1050	02-Jul	02-Jul	0	DRS	6.9	8.2
13483	YELLOW	M	760	06-Jul	27-Jul	21	DRS	9.3	14.4
13609	YELLOW	M	850	10-Jul	12-Jul	2	DRS	8.7	14.4
13559	YELLOW	M	1200	12-Jul	15-Jul	3	ASS	9.4	7.5
1094	YELLOW	M	1080	12-Jul	18-Jul	6	DRS	8.7	14.0
1081	YELLOW	M	1130	12-Jul	18-Jul	6	ASS	8.9	18.1
1041	YELLOW	M	1040	13-Jul	26-Jul	13	ASS	8.4	25.1
14952	BLUE	F	1030	16-Jul	25-Jul	9	ASS	7.2	23.0
14765	BLUE	F	990	21-Jul	22-Jul	1	DRS	6.5	11.4
14792	BLUE	F	1040	26-Jul	27-Jul	1	DRS	8.8	8.0

[a] Recovery sources: URS = upstream roving creel survey
DRS = downstream creel survey
ASS = access-site creel survey

[b] Tag number not recorded but time of release known from color of tag.

Appendix A2. Age group composition of chinook salmon caught by drift gill
nets in the Kenai River, 1989.

| Stratum | Sex | Statistic | Age Group | | | | | TOTAL |
			1.2	1.3	1.4	1.5	Other[a]	
5/17 - 5/31	Female	Sample Size		11	63	4		78
		% of Sample		7.0	39.9	2.5		49.4
		SE		2.03	3.91	1.25		3.99
	Male	Sample Size	1	12	55	9	3	80
		% of Sample	0.6	7.6	34.8	5.7	1.9	50.6
		SE	0.63	2.11	3.80	1.85	1.09	3.99
	Combined	Sample Size	1	23	118	13	3	158
		% of Sample	0.6	14.6	74.7	8.2	1.9	100.0
		SE	0.63	2.81	3.47	2.68	1.09	
6/01 - 6/15	Female	Sample Size		18	109	9		136
		% of Sample		7.4	44.9	3.7		56.0
		SE		1.68	3.20	1.21		3.19
	Male	Sample Size	12	29	59	7		107
		% of Sample	4.9	11.9	24.3	2.9		44.0
		SE	1.39	2.08	2.76	1.08		3.19
	Combined	Sample Size	12	47	168	16		243
		% of Sample	4.9	19.3	69.1	6.6		100.0
		SE	1.39	2.54	2.97	1.59		
6/16 - 6/30	Female	Sample Size		12	99	13		124
		% of Sample		4.3	35.6	4.7		44.6
		SE		1.22	2.88	1.27		2.99
	Male	Sample Size	14	20	98	22		154
		% of Sample	5.0	7.2	35.3	7.9		55.4
		SE	1.31	1.55	2.87	1.62		2.99
	Combined	Sample Size	14	32	197	35		278
		% of Sample	5.0	11.5	70.9	12.6		100.0
		SE	1.31	1.92	2.73	1.99		

-Continued-

Stratum	Sex	Statistic	\Age Group 1.2	1.3	1.4	1.5	Other[a]	TOTAL
7/01 - 7/15	Female	Sample Size	8	15	86	22	1	132
		% of Sample	3.3	6.1	35.2	9.0	0.4	54.1
		SE	1.14	1.54	3.06	1.84	0.41	3.20
	Male	Sample Size	22	16	61	13		112
		% of Sample	9.0	6.6	25.0	5.3		45.9
		SE	1.84	1.59	2.78	1.44		3.20
	Combined	Sample Size	30	31	147	35	1	244
		% of Sample	12.3	12.7	60.2	14.3	0.4	00.0
		SE	2.11	2.14	3.14	2.25	0.41	
7/16 - 7/31	Female	Sample Size	6	19	100	15		140
		% of Sample	2.6	8.2	43.3	6.5		60.6
		SE	1.05	1.81	3.27	1.62		3.22
	Male	Sample Size	14	12	55	10		91
		% of Sample	6.1	5.2	23.8	4.3		39.4
		SE	1.57	1.46	2.81	1.34		3.22
	Combined	Sample Size	20	31	155	25		231
		% of Sample	8.7	13.4	67.1	10.8		100.0
		SE	1.85	2.25	3.10	2.05		
8/01 - 8/07	Female	Sample Size		6	58	9	4	77
		% of Sample		4.4	42.3	6.6	2.9	56.2
		SE		1.75	4.24	2.12	1.43	4.25
	Male	Sample Size	12	7	35	5	1	60
		% of Sample	8.8	5.1	25.5	3.6	0.7	43.8
		SE	2.42	1.89	3.74	1.61	0.73	4.25
	Combined	Sample Size	12	13	93	14	5[b]	137
		% of Sample	8.8	9.5	67.9	10.2	3.6	100.0
		SE	2.42	2.51	4.00	2.60	1.59	

[a] Age groups 2.4 and 2.5 combined.
[b] Age groups 1.1, 2.1, 2.2, 2.3, and 3.1 combined.

Appendix A3. Mean length (mm) by sex and age group of chinook salmon caught by drift gill nets in the Kenai River, 1989.

Stratum	Sex	Statistic	1.2	1.3	1.4	1.5	2.4	2.5	TOTAL
5/17 - 5/31	Female	Sample Size		11	63	4			78
		Mean Length		812	940	1,005			925
		SE		15.2	9.6	29.0			9.8
	Male	Sample Size	1	12	55	9	1	2	80
		Mean Length	650	765	1,006	1,116	730	965	973
		SE		16.4	10.4	23.2		55.0	14.5
	Combined	Sample Size	1	23	118	13	1	2	158
		Mean Length	650	787	971	1,082	730	965	949
		SE		12.0	7.7	23.0		55.0	9.0
6/01 - 6/15	Female	Sample Size		18	109	9			136
		Mean Length		800	952	1,017			936
		SE		13.3	5.8	26.0			7.1
	Male	Sample Size	12	29	59	7			107
		Mean Length	647	756	1,019	1,139			914
		SE	8.2	11.2	11.6	36.2			16.8
	Combined	Sample Size	12	47	168	16			243
		Mean Length	647	773	976	1,070			926
		SE	8.2	9.1	6.0	26.0			8.4

- Continued -

Stratum	Sex	Statistic	Age Group					TOTAL
			1.2	1.3	1.4	1.5	1.6	
6/16 - 6/30	Female	Sample Size		12	99	13		124
		Mean Length		805	996	1,074		986
		SE		23.1	8.3	13.7		9.1
	Male	Sample Size	14	20	98	22		154
		Mean Length	652	802	1,073	1,153		1,011
		SE	7.6	25.1	7.5	15.3		13.6
	Combined	Sample Size	14	32	197	35		278
		Mean Length	652	803	1,035	1,124		1,000
		SE	7.6	17.7	6.2	12.6		8.6
7/01 - 7/15	Female	Sample Size	8	15	86	22	1	132
		Mean Length	672	807	1,019	1,069	1,030	982
		SE	9.8	16.7	6.9	11.4		10.7
	Male	Sample Size	22	16	61	13		112
		Mean Length	635	775	1,082	1,145		958
		SE	11.8	18.2	9.7	11.9		19.5
	Combined	Sample Size	30	31	147	35	1	244
		Mean Length	645	791	1,045	1,097	1,030	971
		SE	9.4	12.5	6.2	10.4		10.7

- Continued -

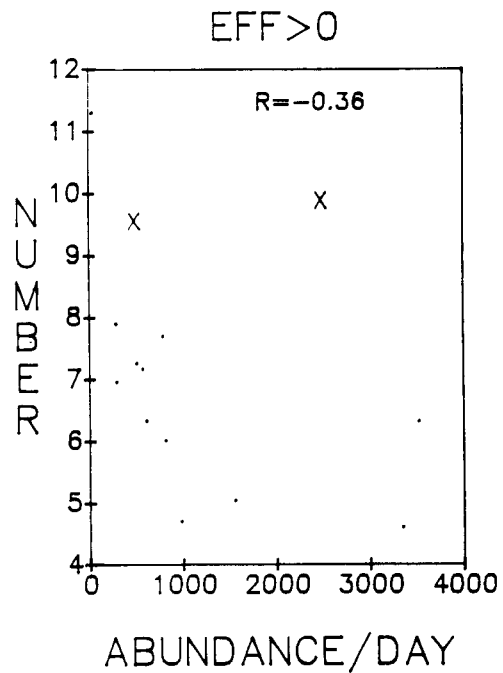| Stratum	Sex	Statistic	Age Group 1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.3	3.1	TOTAL
7/16 - 7/31	Female	Sample Size		6	19	100	15					140
		Mean Length		648	848	1,017	1,034					980
		SE		20.3	15.6	5.3	12.4					9.0
	Male	Sample Size		14	12	55	10					91
		Mean Length		653	851	1059	1128					977
		SE		10.9	31.0	9.1	10.7					18.0
	Combined	Sample Size		20	31	155	25					231
		Mean Length		652	849	1,032	1,072					979
		SE		9.4	15.0	4.9	12.6					8.9
8/01 - 8/11	Female	Sample Size	1		6	58	9		1	1	1	77
		Mean Length	990		937	1,003	1,049		870	950	930	1,000
		SE			32.8	7.6	20.4					7.4
	Male	Sample Size		12	7	35	5	1				60
		Mean Length		630	804	1,058	1,120	1,150				950
		SE		11.3	22.1	11.6	20.0					24.8
	Combined	Sample Size	1	12	13	93	14	1	1	1	1	137
		Mean Length	990	630	865	1,024	1,074	1,150	870	950	930	978
		SE		11.3	26.5	7.0	17.2					11.8

APPENDIX B - FIGURES
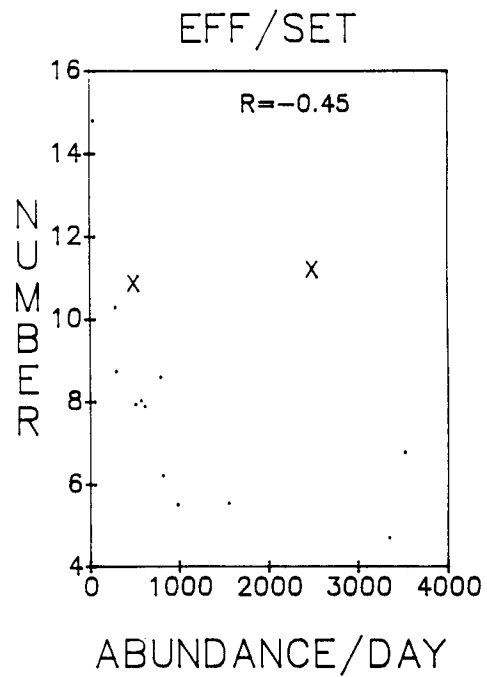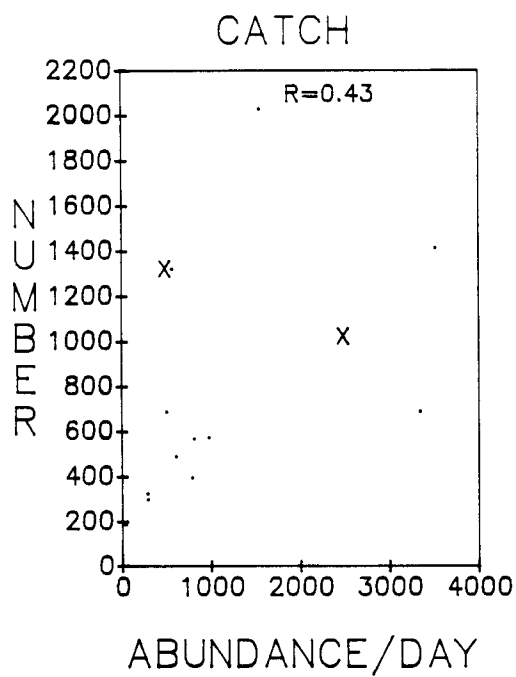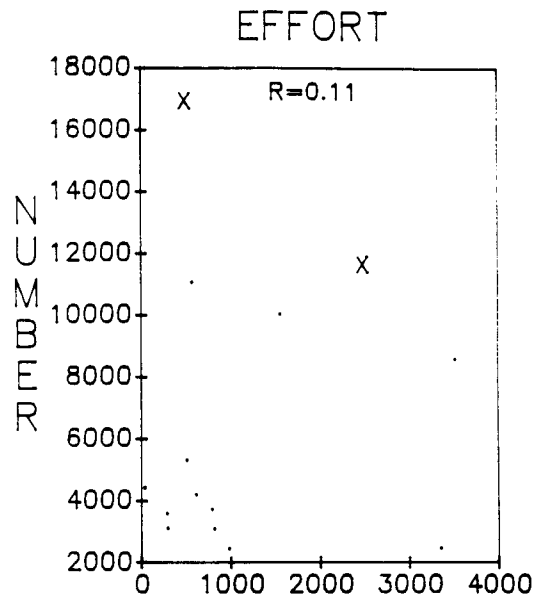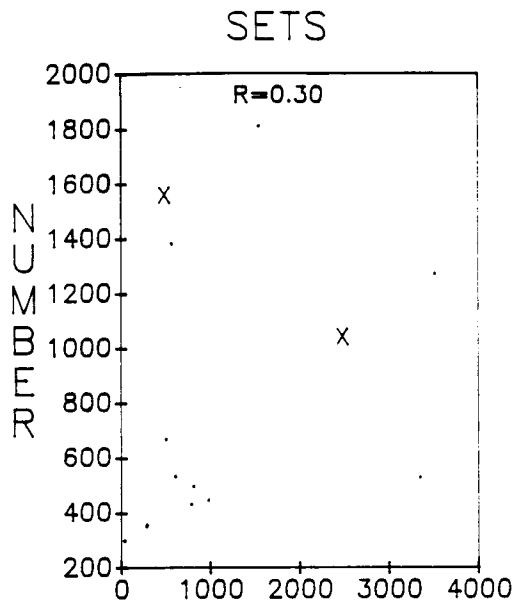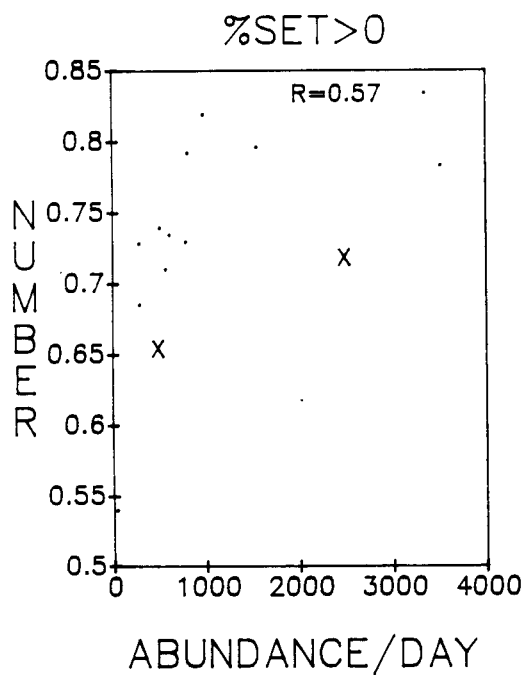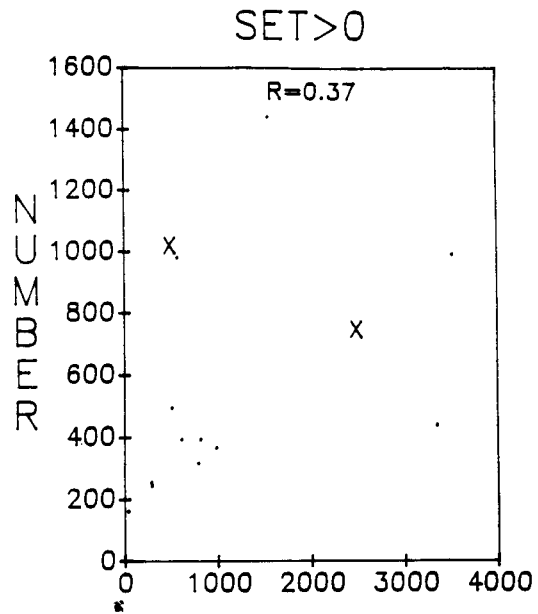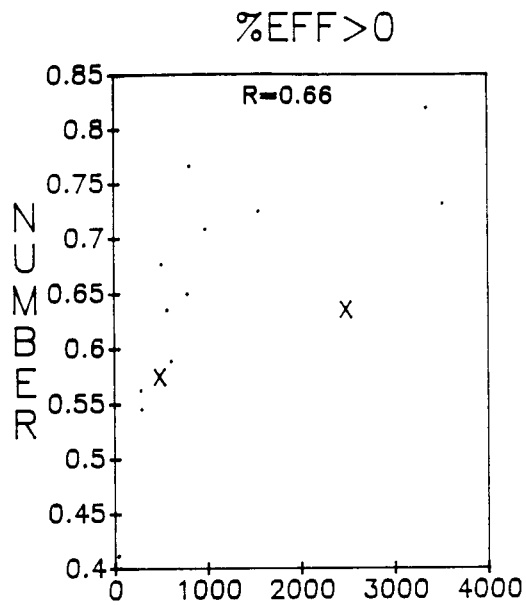
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Appendix B1. Scatter-plot for catch-effort statistics versus abundance per day estimated in the Kenai River, 1986-1989.

CAT/SET

R=0.61

CAT/EFF

R=0.58

EFF=0

R=-0.1

ABUNDANCE/DAY

EFF=0/SET

R=-0.53

ABUNDANCE/DAY

-Continued-

Appendix B1.   (Page 2 of 4).

-Continued-

Appendix B1. (Page 3 of 4).

Appendix B1. (Page 4 of 4).